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CALCULATION OF THE LAMINAR VISCOSITY OF A GASEOUS MIXTURE FOR 0--ETC(U)  
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TECHNICAL REPORT RD-80-2

CALCULATION OF THE LAMINAR VISCOSITY  
OF A GASEOUS MIXTURE FOR GAS DYNAMIC  
MIXING COMPARISONS FOR A REACTING  
SHEAR LAYER

B.J. Walker  
Systems Simulation and Development Directorate  
US Army Missile Laboratory

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October 1979



U.S. ARMY MISSILE COMMAND  
Redstone Arsenal, Alabama 35809

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## I. INTRODUCTION

In the process of evaluating various turbulent mixing models, the question kept arising of how the turbulent flow differed from the laminar flow. A comparison of two different turbulence kinetic energy models is given in Walker [4] and, in addition, the use of a laminar viscosity model for comparison with the turbulence models is discussed. This was accomplished for a reacting shear layer for which experimental results had been obtained. Therefore, the techniques and results presented herein were utilized to make qualitative comparisons.

Additionally the techniques presented in this work are directly useful in the chemical laser program because of the fine scale mixing in the nozzles and the low pressure operation in the laser cavity. The coding presented herein is applicable only for a  $N_2$ ,  $O_2$ ,  $NO$ ,  $NO_2$ , and  $O_3$  system but minor coding changes will make these results applicable for any gas at low pressure.

## II. CUBIC SPLINE INTERPOLATION

In order to determine the laminar viscosity of the various gases involved as a function of temperature, it is necessary to interpolation *Table 1* for temperatures not given. This could be done utilizing a simple linear interpolation scheme. However, a more accurate scheme which does not take an excessive amount of computational time is cubic spline interpolation. This is a piecewise cubic interpolation scheme that matches the function and its slope at each of the known points given in *Table 1*. Cubic spline interpolation is currently very popular and will be utilized here.

The only problem with this scheme occurs at the end points of the interval. The requirement that the slopes be matched at this point between the piecewise cubic sections cannot be met since no other point is available from which to calculate the slope. Therefore a special treatment for the end points was necessary and the use of a Lagrangian polynomial was chosen.

The Lagrangian polynomial is given by

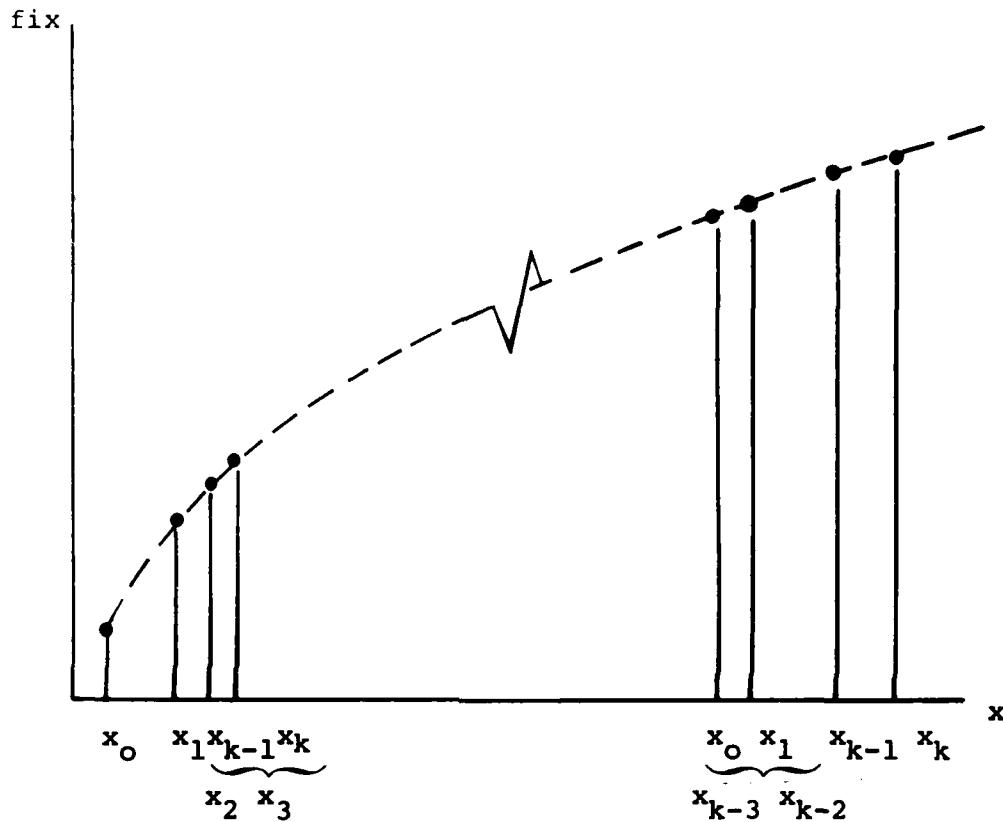
$$p(x) = \sum_{k=0}^n f(x_k) l_k(x) \quad (1)$$

TABLE 1. FUNCTIONS FOR PREDICTION OF TRANSPORT PROPERTIES OF GASES AT LOW DENSITIES [3]

$\kappa T/\epsilon$	$\Omega_\mu$						
0.30	2.785	1.25	1.424	2.50	1.093	4.50	0.9464
0.35	2.628	1.30	1.399	2.60	1.081	4.60	0.9422
0.40	2.492	1.35	1.375	2.70	1.069	4.70	0.9382
0.45	2.368	1.40	1.353	2.80	1.058	4.80	0.9343
		1.45	1.333	2.90	1.048	4.90	0.9305
0.50	2.257	1.50	1.314	3.00	1.039	5.0	0.9269
0.55	2.156	1.55	1.296	3.10	1.030	6.0	0.8963
0.60	2.065	1.60	1.279	3.20	1.022	7.0	0.8727
0.65	1.982	1.65	1.264	3.30	1.014	8.0	0.8538
0.70	1.908	1.70	1.248	3.40	1.007	9.0	0.8379
0.75	1.841	1.75	1.234	3.50	0.9999	10.0	0.8242
0.80	1.780	1.80	1.221	3.60	0.9932	20.0	0.7432
0.85	1.725	1.85	1.209	3.70	0.9870	30.0	0.7005
0.90	1.675	1.90	1.197	3.80	0.9811	40.0	0.6718
0.95	1.629	1.95	1.186	3.90	0.9755	50.0	0.6504
1.00	1.587	2.00	1.175	4.00	0.9700	60.0	0.6335
1.05	1.549	2.10	1.156	4.10	0.9649	70.0	0.6194
1.10	1.514	2.20	1.138	4.20	0.9600	80.0	0.6076
1.15	1.482	2.30	1.122	4.30	0.9553	90.0	0.5973
1.20	1.452	2.40	1.107	4.40	0.9507	100.0	0.5882

where

$$l_k(x) = \frac{g_k(x)}{g_k(x_k)} \prod_{\substack{i=0 \\ i \neq k}}^n \frac{(x - x_i)}{x_k - x_i} \quad (2)$$



**Figure 1. End points nomenclature.**

For the end points shown.

$$p(x) = f(x_0)l_0(x) + f(x_1)l_1(x) + f(x_{k-1})l_{k-1}(x) + f(x_k)l_k(x) \quad (3)$$

$$l_0(x) = \left\{ \frac{x - x_1}{x_0 - x_1} \right\} \left\{ \frac{x - x_{k-1}}{x_0 - x_{k-1}} \right\} \left\{ \frac{x - x_k}{x_0 - x_k} \right\}$$

$$l_1(x) = \left\{ \frac{x - x_0}{x_1 - x_0} \right\} \left\{ \frac{x - x_{k-1}}{x_1 - x_{k-1}} \right\} \left\{ \frac{x - x_k}{x_1 - x_k} \right\} \quad (4)$$

$$l_{k-1}(x) = \left\{ \frac{x - x_0}{x_{k-1} - x_0} \right\} \left\{ \frac{x - x_1}{x_{k-1} - x_1} \right\} \left\{ \frac{x - x_k}{x_{k-1} - x_k} \right\}$$

$$l_k(x) = \left\{ \frac{x - x_0}{x_k - x_0} \right\} \left\{ \frac{x - x_1}{x_k - x_1} \right\} \left\{ \frac{x - x_{k-1}}{x_k - x_{k-1}} \right\}$$

Now

$$f(x_k) = \text{const}$$

$$x_k - x_i = \text{const}$$

hence

$$\frac{dp(x)}{dx} = f(x_0) l_0'(x) + f(x_1) l_1'(x) + f(x_{k-1}) l_{k-1}'(x) + f(x_k) l_k'(x) \quad (5)$$

Now

$$l_0(x) = \frac{1}{(x_0 - x_1)(x_0 - x_{k-1})(x_0 - x_k)} *$$

$$\left\{ (x - x_1)(x - x_{k-1})(x - x_k) \right\}$$

hence

$$l'_0(x) = (x - x_1) \frac{d}{dx} (x^2 - xx_{k-1} - xx_k + x_{k-1}x_k) *$$

$$\frac{\left\{ \frac{1}{(x_0 - x_1)(x_0 - x_{k-1})(x_0 - x_k)} \right\} + (x - x_{k-1})(x - x_k) *}{\left\{ \frac{1}{(x_0 - x_1)(x_0 - x_{k-1})(x_0 - x_k)} \right\}}$$

$$l'_0(x) = \frac{1}{(x_0 - x_1)(x_0 - x_{k-1})(x_0 - x_k)} \left[ (x - x_1)(2x - x_{k-1} - x_k) + (x - x_{k-1})(x - x_k) \right]$$

and

$$l'_0(x) = \frac{(x - x_1)(2x - x_{k-1} - x_k) + (x - x_{k-1})(x - x_k)}{(x_0 - x_1)(x_0 - x_{k-1})(x_0 - x_k)} \quad (6)$$

$$l'_1(x) = \frac{1}{x_1 - x_0 (x_1 - x_{k-1})(x_1 - x_k)} *$$

$$\left\{ (x - x_0)(x - x_{k-1})(x - x_k) \right\}$$

$$l'_1(x) = \frac{1}{(x_1 - x_0)(x_1 - x_{k-1})(x_1 - x_k)} \left[ (x - x_0) \right. \\ \left. \frac{d}{dx} \left\{ x^2 - xx_{k-1} - xx_k + x_k x_{k-1} \right\} + (x - x_{k-1})(x - x_k) \right]$$

$$l_1'(x) = \frac{1}{(x_1 - x_o)(x_1 - x_{k-1})(x_1 - x_k)} \left[ (x - x_o) \right. \\ \left. \{2x - x_{k-1} - x_k\} + (x - x_{k-1})(x - x_k) \right]$$

$$l_1'(x) = \frac{(x - x_o)(2x - x_{k-1} - x_k) + (x - x_{k-1})(x - x_k)}{(x_1 - x_o)(x_1 - x_{k-1})(x_1 - x_k)} \quad (7)$$

$$l_{k-1}'(x) = \frac{1}{(x_{k-1} - x_o)(x_{k-1} - x_1)(x_{k-1} - x_k)} \left[ (x - x_o) \right. \\ \left. (x - x_1)(x - x_k) \right]$$

$$l_{k-1}'(x) = \frac{1}{(x_{k-1} - x_o)(x_{k-1} - x_1)(x_{k-1} - x_k)} \left[ (x - x_o) \right. \\ \left. \frac{d}{dx} \{x^2 - x_1x - x_kx + x_1x_k\} + (x - x_1)(x - x_k) \right]$$

$$l_{k-1}'(x) = \frac{1}{(x_{k-1} - x_o)(x_{k-1} - x_1)(x_{k-1} - x_k)} \left[ (x - x_o) \right. \\ \left. (2x - x_1 - x_k) + (x - x_1)(x - x_k) \right]$$

$$l_{k-1}'(x) = \frac{(x - x_o)(2x - x_1 - x_k) + (x - x_1)(x - x_k)}{(x_{k-1} - x_o)(x_{k-1} - x_1)(x_{k-1} - x_k)} \quad (8)$$

$$l_k'(x) = \frac{1}{(x_k - x_o)(x_k - x_1)(x_k - x_{k-1})} \left[ (x - x_o) \right. \\ \left. (x - x_1)(x - x_{k-1}) \right]$$

$$l_k'(x) = \frac{1}{(x_k - x_0)(x_k - x_1)(x_k - x_{k-1})} \left[ (x - x_0) \frac{d}{dx} \left\{ x^2 - xx_1 - xx_{k-1} + x_1 x_{k-1} \right\} + (x - x_1)(x - x_{k-1}) \right]$$

$$l_k'(x) = \frac{1}{(x_k - x_0)(x_k - x_1)(x_k - x_{k-1})} \left[ (x - x_0) (2x - x_1 - x_{k-1}) + (x - x_1)(x - x_{k-1}) \right]$$

$$l_k'(x) = \frac{(x - x_0)(2x - x_1 - x_{k-1}) + (x - x_1)(x - x_{k-1})}{(x_k - x_0)(x_k - x_1)(x_k - x_{k-1})} \quad (9)$$

Hence the end point slopes are given by:

$$\begin{aligned} \frac{df(x)}{dx} &= f(x_0)l_0'(x) + f(x_1)l_1'(x) + f(x_{k-1})l_{k-1}'(x) \\ &+ f(x_k)l_k'(x) \end{aligned} \quad (10)$$

where:

$$l_0'(x) = \frac{(x - x_1)(2x - x_{k-1} - x_k) + (x - x_{k-1})(x - x_k)}{(x_0 - x_1)(x_0 - x_{k-1})(x_0 - x_k)}$$

$$l_1'(x) = \frac{(x - x_0)(2x - x_{k-1} - x_k) + (x - x_{k-1})(x - x_k)}{(x_1 - x_0)(x_1 - x_{k-1})(x_1 - x_k)}$$

$$l_{k-1}'(x) = \frac{(x - x_0)(2x - x_1 - x_k) + (x - x_1)(x - x_k)}{(x_{k-1} - x_0)(x_{k-1} - x_1)(x_{k-1} - x_k)}$$

$$l_k'(x) = \frac{(x - x_0)(2x - x_1 - x_{k-1}) + (x - x_1)(x - x_{k-1})}{(x_k - x_0)(x_k - x_1)(x_k - x_{k-1})}$$

Now when these equations are used to calculate the left end point slope

$x_{k-1}$  Becomes  $x_2$

$x_k$  Becomes  $x_3$

and when they are used to calculate the right end point slope

$x_0$  Becomes  $x_{k-3}$

$x_1$  Becomes  $x_{k-2}$

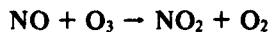
as shown in *Figure 1*.

The special end point treatment was incorporated with a cubic spline interpolation routine developed by Conte and de Boor [1]. The program listing is given in Appendix A. As a test for this generalized routine, the viscosity function  $\Omega_\mu$  was interpolated at several points including input points to determine how well the cubic spline interpolation program was working. *Table 1* gives the known input data for  $\Omega_\mu$  as a function of  $\kappa T/\epsilon$ .

The results of the use of the cubic spline interpolation program are given in *Table 2*. Note that the interpolation scheme gives very smooth results. Also note that the input data is under no restriction as to the regularity of the input function interval i.e.,  $\Delta(\kappa T/\epsilon)$  varies from 0.05-5.0.

### III. MOLECULAR VISCOSITY OF NO<sub>2</sub> AND O<sub>3</sub>

The reacting shear layer that calculations were made for contained the following reaction:



Since the mixed stream includes a combination of these gases, it is necessary to know the laminar viscosities of each of the component gases as a function of temperature. These have

TABLE 2. RESULTS OF CUBIC SPLINE INTERPOLATION ROUTINE  
FOR  $\Omega_4$  ( $kT/e$ ) GIVEN IN TABLE 1.

PT. NO.	X	F(X)
PT. NO.	1	.300000000E+00
PT. NO.	2	.310000000E+00
PT. NO.	3	.320000000E+00
PT. NO.	4	.330000000E+00
PT. NO.	5	.340000000E+00
PT. NO.	6	.350000000E+00
PT. NO.	7	.360000000E+00
PT. NO.	8	.370000000E+00
PT. NO.	9	.380000000E+00
PT. NO.	10	.390000000E+00
PT. NO.	11	.400000000E+00
PT. NO.	12	.410000000E+00
PT. NO.	13	.420000000E+00
PT. NO.	14	.430000000E+00
PT. NO.	15	.440000000E+00
PT. NO.	16	.450000000E+00
PT. NO.	17	.460000000E+00
PT. NO.	18	.470000000E+00
PT. NO.	19	.480000000E+00
PT. NO.	20	.490000000E+00
PT. NO.	21	.500000000E+00
PT. NO.	22	.510000000E+00
PT. NO.	23	.520000000E+00
PT. NO.	24	.530000000E+00
PT. NO.	25	.540000000E+00
PT. NO.	26	.550000000E+00
PT. NO.	27	.560000000E+00
PT. NO.	28	.570000000E+00
PT. NO.	29	.580000000E+00
PT. NO.	30	.590000000E+00
PT. NO.	31	.600000000E+00
PT. NO.	32	.610000000E+00
PT. NO.	33	.620000000E+00
PT. NO.	34	.630000000E+00
PT. NO.	35	.640000000E+00
PT. NO.	36	.650000000E+00
PT. NO.	37	.660000000E+00
PT. NO.	38	.670000000E+00
PT. NO.	39	.680000000E+00
PT. NO.	40	.690000000E+00
PT. NO.	41	.700000000E+00
PT. NO.	42	.710000000E+00
PT. NO.	43	.720000000E+00
PT. NO.	44	.730000000E+00
PT. NO.	45	.740000000E+00
PT. NO.	46	.750000000E+00
PT. NO.	47	.760000000E+00
PT. NO.	48	.770000000E+00
PT. NO.	49	.780000000E+00
PT. NO.	50	.790000000E+00
PT. NO.	51	.800000000E+00
PT. NO.	52	.810000000E+00
PT. NO.	53	.820000000E+00
PT. NO.	54	.830000000E+00
PT. NO.	55	.840000000E+00
PT. NO.	56	.850000000E+00
PT. NO.	57	.860000000E+00
PT. NO.	58	.870000000E+00
PT. NO.	59	.880000000E+00
PT. NO.	60	.890000000E+00
PT. NO.	61	.900000000E+00
PT. NO.	62	.910000000E+00
PT. NO.	63	.920000000E+00
PT. NO.	64	.930000000E+00
PT. NO.	65	.940000000E+00
PT. NO.	66	.950000000E+00
PT. NO.	67	.960000000E+00
PT. NO.	68	.970000000E+00
PT. NO.	69	.980000000E+00
PT. NO.	70	.990000000E+00
PT. NO.	71	.100000000E+01
PT. NO.	72	.101000000E+01
PT. NO.	73	.102000000E+01
PT. NO.	74	.103000000E+01
PT. NO.	75	.104000000E+01
PT. NO.	76	.105000000E+01
PT. NO.	77	.106000000E+01
PT. NO.	78	.107000000E+01
PT. NO.	79	.108000000E+01
PT. NO.	80	.109000000E+01
PT. NO.	81	.110000000E+01

TABLE 2. (CONTINUED)

PT, NO, z	82	xz	111000000E+01	F(x) =	15073743E+01
PT, NO, z	83	xz	112000000E+01	F(x) =	15004072E+01
PT, NO, z	84	xz	113000000E+01	F(x) =	14944955E+01
PT, NO, z	85	xz	114000000E+01	F(x) =	1482058E+01
PT, NO, z	86	xz	115000000E+01	F(x) =	14820000E+01
PT, NO, z	87	xz	116000000E+01	F(x) =	14758467E+01
PT, NO, z	88	xz	117000000E+01	F(x) =	14698020E+01
PT, NO, z	89	xz	118000000E+01	F(x) =	14638044E+01
PT, NO, z	90	xz	119000000E+01	F(x) =	14578706E+01
PT, NO, z	91	xz	120000000E+01	F(x) =	14520000E+01
PT, NO, z	92	xz	121000000E+01	F(x) =	14461940E+01
PT, NO, z	93	xz	122000000E+01	F(x) =	14404694E+01
PT, NO, z	94	xz	123000000E+01	F(x) =	14348447E+01
PT, NO, z	95	xz	124000000E+01	F(x) =	1429317E+01
PT, NO, z	96	xz	125000000E+01	F(x) =	14240000E+01
PT, NO, z	97	xz	126000000E+01	F(x) =	14188054E+01
PT, NO, z	98	xz	127000000E+01	F(x) =	14137427E+01
PT, NO, z	99	xz	128000000E+01	F(x) =	14087773E+01
PT, NO, z	100	xz	129000000E+01	F(x) =	14038744E+01
PT, NO, z	101	xz	130000000E+01	F(x) =	13990000E+01
PT, NO, z	102	xz	131000000E+01	F(x) =	13941292E+01
PT, NO, z	103	xz	132000000E+01	F(x) =	13844500E+01
PT, NO, z	104	xz	133000000E+01	F(x) =	13796454E+01
PT, NO, z	105	xz	134000000E+01	F(x) =	13750000E+01
PT, NO, z	106	xz	135000000E+01	F(x) =	13704096E+01
PT, NO, z	107	xz	136000000E+01	F(x) =	13659145E+01
PT, NO, z	108	xz	137000000E+01	F(x) =	13615144E+01
PT, NO, z	109	xz	138000000E+01	F(x) =	13572134E+01
PT, NO, z	110	xz	139000000E+01	F(x) =	13529134E+01
PT, NO, z	111	xz	140000000E+01	F(x) =	13530000E+01
PT, NO, z	112	xz	141000000E+01	F(x) =	13488734E+01
PT, NO, z	113	xz	142000000E+01	F(x) =	13448224E+01
PT, NO, z	114	xz	143000000E+01	F(x) =	13400357E+01
PT, NO, z	115	xz	144000000E+01	F(x) =	13368499E+01
PT, NO, z	116	xz	145000000E+01	F(x) =	13330000E+01
PT, NO, z	117	xz	146000000E+01	F(x) =	13291279E+01
PT, NO, z	118	xz	147000000E+01	F(x) =	13252471E+01
PT, NO, z	119	xz	148000000E+01	F(x) =	13216824E+01
PT, NO, z	120	xz	149000000E+01	F(x) =	13177143E+01
PT, NO, z	121	xz	150000000E+01	F(x) =	13148000E+01
PT, NO, z	122	xz	151000000E+01	F(x) =	13103394E+01
PT, NO, z	123	xz	152000000E+01	F(x) =	13067044E+01
PT, NO, z	124	xz	153000000E+01	F(x) =	13031132E+01
PT, NO, z	125	xz	154000000E+01	F(x) =	12995174E+01
PT, NO, z	126	xz	155000000E+01	F(x) =	12950000E+01
PT, NO, z	127	xz	156000000E+01	F(x) =	12924674E+01
PT, NO, z	128	xz	157000000E+01	F(x) =	12887249E+01
PT, NO, z	129	xz	158000000E+01	F(x) =	12855443E+01
PT, NO, z	130	xz	159000000E+01	F(x) =	12822104E+01
PT, NO, z	131	xz	160000000E+01	F(x) =	12794044E+01
PT, NO, z	132	xz	161000000E+01	F(x) =	12755244E+01
PT, NO, z	133	xz	162000000E+01	F(x) =	12725674E+01
PT, NO, z	134	xz	163000000E+01	F(x) =	12700054E+01
PT, NO, z	135	xz	164000000E+01	F(x) =	12670420E+01
PT, NO, z	136	xz	165000000E+01	F(x) =	12640000E+01
PT, NO, z	137	xz	166000000E+01	F(x) =	12584411E+01
PT, NO, z	138	xz	167000000E+01	F(x) =	12576032E+01
PT, NO, z	139	xz	168000000E+01	F(x) =	12533611E+01
PT, NO, z	140	xz	169000000E+01	F(x) =	12511254E+01
PT, NO, z	141	xz	170000000E+01	F(x) =	12480000E+01
PT, NO, z	142	xz	171000000E+01	F(x) =	12450124E+01
PT, NO, z	143	xz	172000000E+01	F(x) =	12421487E+01
PT, NO, z	144	xz	173000000E+01	F(x) =	12393743E+01
PT, NO, z	145	xz	174000000E+01	F(x) =	12366720E+01
PT, NO, z	146	xz	175000000E+01	F(x) =	12334000E+01
PT, NO, z	147	xz	176000000E+01	F(x) =	12313399E+01
PT, NO, z	148	xz	177000000E+01	F(x) =	122246072E+01
PT, NO, z	149	xz	178000000E+01	F(x) =	122260446E+01
PT, NO, z	150	xz	179000000E+01	F(x) =	122235446E+01
PT, NO, z	151	xz	180000000E+01	F(x) =	12210000E+01
PT, NO, z	152	xz	181000000E+01	F(x) =	12185477E+01
PT, NO, z	153	xz	182000000E+01	F(x) =	121616425E+01
PT, NO, z	154	xz	183000000E+01	F(x) =	12137434E+01
PT, NO, z	155	xz	184000000E+01	F(x) =	12113445E+01
PT, NO, z	156	xz	185000000E+01	F(x) =	12090000E+01
PT, NO, z	157	xz	186000000E+01	F(x) =	12065P12E+01
PT, NO, z	158	xz	187000000E+01	F(x) =	12041444E+01
PT, NO, z	159	xz	188000000E+01	F(x) =	12017258E+01
PT, NO, z	160	xz	189000000E+01	F(x) =	11993352E+01
PT, NO, z	161	xz	190000000E+01	F(x) =	11470000E+01
PT, NO, z	162	xz	191000000E+01	F(x) =	1147355E+01

TABLE 2. (CONTINUED)

PT, NO. = 163	X = .19200000E+01	F(X) = .11925264E+01
PT, NO. = 164	X = .19300000E+01	F(X) = .11934394E+01
PT, NO. = 165	X = .19400000E+01	F(X) = .11941417E+01
PT, NO. = 166	X = .19500000E+01	F(X) = .11950000E+01
PT, NO. = 167	X = .19600000E+01	F(X) = .11960000E+01
PT, NO. = 168	X = .19700000E+01	F(X) = .11975614E+01
PT, NO. = 169	X = .19800000E+01	F(X) = .11983405E+01
PT, NO. = 170	X = .19900000E+01	F(X) = .11993461E+01
PT, NO. = 171	X = .20000000E+01	F(X) = .11750000E+01
PT, NO. = 172	X = .20100000E+01	F(X) = .11729148E+01
PT, NO. = 173	X = .20200000E+01	F(X) = .11708497E+01
PT, NO. = 174	X = .20300000E+01	F(X) = .11689324E+01
PT, NO. = 175	X = .20400000E+01	F(X) = .11670118E+01
PT, NO. = 176	X = .20500000E+01	F(X) = .11651228E+01
PT, NO. = 177	X = .20600000E+01	F(X) = .11632755E+01
PT, NO. = 178	X = .20700000E+01	F(X) = .11614440E+01
PT, NO. = 179	X = .20800000E+01	F(X) = .11596262E+01
PT, NO. = 180	X = .20900000E+01	F(X) = .11578142E+01
PT, NO. = 181	X = .21000000E+01	F(X) = .11560000E+01
PT, NO. = 182	X = .21100000E+01	F(X) = .11541777E+01
PT, NO. = 183	X = .21200000E+01	F(X) = .11523493E+01
PT, NO. = 184	X = .21300000E+01	F(X) = .11505190E+01
PT, NO. = 185	X = .21400000E+01	F(X) = .11486904E+01
PT, NO. = 186	X = .21500000E+01	F(X) = .11468692E+01
PT, NO. = 187	X = .21600000E+01	F(X) = .11450579E+01
PT, NO. = 188	X = .21700000E+01	F(X) = .11432613E+01
PT, NO. = 189	X = .21800000E+01	F(X) = .11416833E+01
PT, NO. = 190	X = .21900000E+01	F(X) = .11397282E+01
PT, NO. = 191	X = .22000000E+01	F(X) = .11380000E+01
PT, NO. = 192	X = .22100000E+01	F(X) = .11363018E+01
PT, NO. = 193	X = .22200000E+01	F(X) = .11346322E+01
PT, NO. = 194	X = .22300000E+01	F(X) = .11329486E+01
PT, NO. = 195	X = .22400000E+01	F(X) = .11313645E+01
PT, NO. = 196	X = .22500000E+01	F(X) = .11297594E+01
PT, NO. = 197	X = .22600000E+01	F(X) = .11281887E+01
PT, NO. = 198	X = .22700000E+01	F(X) = .11266240E+01
PT, NO. = 199	X = .22800000E+01	F(X) = .11250726E+01
PT, NO. = 200	X = .22900000E+01	F(X) = .11235321E+01
PT, NO. = 201	X = .23000000E+01	F(X) = .11220000E+01
PT, NO. = 202	X = .23100000E+01	F(X) = .11204741E+01
PT, NO. = 203	X = .23200000E+01	F(X) = .11189540E+01
PT, NO. = 204	X = .23300000E+01	F(X) = .11174397E+01
PT, NO. = 205	X = .23400000E+01	F(X) = .11159311E+01
PT, NO. = 206	X = .23500000E+01	F(X) = .11144283E+01
PT, NO. = 207	X = .23600000E+01	F(X) = .11129313E+01
PT, NO. = 208	X = .23700000E+01	F(X) = .11114399E+01
PT, NO. = 209	X = .23800000E+01	F(X) = .11099543E+01
PT, NO. = 210	X = .23900000E+01	F(X) = .11084743E+01
PT, NO. = 211	X = .24000000E+01	F(X) = .11070000E+01
PT, NO. = 212	X = .24100000E+01	F(X) = .11055318E+01
PT, NO. = 213	X = .24200000E+01	F(X) = .11040718E+01
PT, NO. = 214	X = .24300000E+01	F(X) = .11026227E+01
PT, NO. = 215	X = .24400000E+01	F(X) = .11011670E+01
PT, NO. = 216	X = .24500000E+01	F(X) = .10997673E+01
PT, NO. = 217	X = .24600000E+01	F(X) = .10982663E+01
PT, NO. = 218	X = .24700000E+01	F(X) = .10969464E+01
PT, NO. = 219	X = .24800000E+01	F(X) = .10956304E+01
PT, NO. = 220	X = .24900000E+01	F(X) = .10943007E+01
PT, NO. = 221	X = .25000000E+01	F(X) = .10930000E+01
PT, NO. = 222	X = .25100000E+01	F(X) = .10917297E+01
PT, NO. = 223	X = .25200000E+01	F(X) = .10904667E+01
PT, NO. = 224	X = .25300000E+01	F(X) = .10892465E+01
PT, NO. = 225	X = .25400000E+01	F(X) = .10880644E+01
PT, NO. = 226	X = .25500000E+01	F(X) = .10868773E+01
PT, NO. = 227	X = .25600000E+01	F(X) = .10856946E+01
PT, NO. = 228	X = .25700000E+01	F(X) = .10845274E+01
PT, NO. = 229	X = .25800000E+01	F(X) = .10833563E+01
PT, NO. = 230	X = .25900000E+01	F(X) = .10821420E+01
PT, NO. = 231	X = .26000000E+01	F(X) = .10810000E+01
PT, NO. = 232	X = .26100000E+01	F(X) = .10798073E+01
PT, NO. = 233	X = .26200000E+01	F(X) = .10786054E+01
PT, NO. = 234	X = .26300000E+01	F(X) = .10773973E+01
PT, NO. = 235	X = .26400000E+01	F(X) = .10761657E+01
PT, NO. = 236	X = .26500000E+01	F(X) = .10749733E+01
PT, NO. = 237	X = .26600000E+01	F(X) = .10737631E+01
PT, NO. = 238	X = .26700000E+01	F(X) = .10725579E+01
PT, NO. = 239	X = .26800000E+01	F(X) = .10713604E+01
PT, NO. = 240	X = .26900000E+01	F(X) = .10701735E+01
PT, NO. = 241	X = .27000000E+01	F(X) = .10690000E+01
PT, NO. = 242	X = .27100000E+01	F(X) = .10678421E+01
PT, NO. = 243	X = .27200000E+01	F(X) = .10666945E+01
PT, NO. = 244	X = .27300000E+01	F(X) = .10655713E+01
PT, NO. = 245	X = .27400000E+01	F(X) = .10644565E+01
PT, NO. = 246	X = .27500000E+01	F(X) = .10633543E+01

TABLE 2. (CONTINUED)

PT.	NO.	X	267	X=	276000000F+01	F(X)=	10622638E+01
PT.	NO.	X	268	X=	277000000F+01	F(X)=	10611840E+01
PT.	NO.	X	269	X=	278000000F+01	F(X)=	10601141E+01
PT.	NO.	X	270	X=	279000000F+01	F(X)=	10590000E+01
PT.	NO.	X	271	X=	280000000F+01	F(X)=	10580000E+01
PT.	NO.	X	272	X=	281000000F+01	F(X)=	10569443E+01
PT.	NO.	X	273	X=	282000000F+01	F(Y)=	10554166E+01
PT.	NO.	X	274	X=	283000000F+01	F(Y)=	10544877E+01
PT.	NO.	X	275	X=	284000000F+01	F(X)=	10538643E+01
PT.	NO.	X	276	X=	285000000F+01	F(X)=	10528593E+01
PT.	NO.	X	277	X=	286000000F+01	F(X)=	1051416F+01
PT.	NO.	X	278	X=	287000000F+01	F(X)=	10508760E+01
PT.	NO.	X	279	X=	288000000F+01	F(X)=	10499033E+01
PT.	NO.	X	280	X=	289000000F+01	F(X)=	10489444E+01
PT.	NO.	X	281	X=	290000000F+01	F(X)=	10480000E+01
PT.	NO.	X	282	X=	291000000F+01	F(X)=	10470705E+01
PT.	NO.	X	283	X=	292000000F+01	F(X)=	10461540E+01
PT.	NO.	X	284	X=	293000000F+01	F(X)=	1045261F+01
PT.	NO.	X	285	X=	294000000F+01	F(X)=	10443504E+01
PT.	NO.	X	286	X=	295000000F+01	F(X)=	10434544E+01
PT.	NO.	X	287	X=	296000000F+01	F(X)=	1042597E+01
PT.	NO.	X	288	X=	297000000F+01	F(X)=	10416820E+01
PT.	NO.	X	289	X=	298000000F+01	F(Y)=	10407427E+01
PT.	NO.	X	290	X=	299000000F+01	F(X)=	10398495F+01
PT.	NO.	X	291	X=	300000000F+01	F(X)=	10390000E+01
PT.	NO.	X	292	X=	301000000F+01	F(X)=	10380926E+01
PT.	NO.	X	293	X=	302000000F+01	F(X)=	10371792F+01
PT.	NO.	X	294	X=	303000000F+01	F(X)=	10362428E+01
PT.	NO.	X	295	X=	304000000F+01	F(X)=	10353461F+01
PT.	NO.	X	296	X=	305000000F+01	F(X)=	10344321F+01
PT.	NO.	X	297	X=	306000000F+01	F(X)=	10335734E+01
PT.	NO.	X	298	X=	307000000F+01	F(X)=	10326231E+01
PT.	NO.	X	299	X=	308000000F+01	F(X)=	1031733F+01
PT.	NO.	X	300	X=	309000000F+01	F(X)=	10308585E+01
PT.	NO.	X	301	X=	310000000F+01	F(X)=	10300000E+01
PT.	NO.	X	302	X=	311000000F+01	F(X)=	10291102F+01
PT.	NO.	X	303	X=	312000000F+01	F(X)=	10283370E+01
PT.	NO.	X	304	X=	313000000F+01	F(X)=	10275274E+01
PT.	NO.	X	305	X=	314000000F+01	F(X)=	10267291E+01
PT.	NO.	X	306	X=	315000000F+01	F(X)=	10259344E+01
PT.	NO.	X	307	X=	316000000F+01	F(X)=	10251526F+01
PT.	NO.	X	308	X=	317000000F+01	F(X)=	10243688E+01
PT.	NO.	X	309	X=	318000000F+01	F(X)=	10235841F+01
PT.	NO.	X	310	X=	319000000F+01	F(X)=	10227955F+01
PT.	NO.	X	311	X=	320000000F+01	F(X)=	10220000E+01
PT.	NO.	X	312	X=	321000000F+01	F(X)=	10211958E+01
PT.	NO.	X	313	X=	322000000F+01	F(X)=	10203447F+01
PT.	NO.	X	314	X=	323000000F+01	F(X)=	10195696E+01
PT.	NO.	X	315	X=	324000000F+01	F(X)=	10187534E+01
PT.	NO.	X	316	X=	325000000F+01	F(X)=	1017935E+01
PT.	NO.	X	317	X=	326000000F+01	F(X)=	10171302E+01
PT.	NO.	X	318	X=	327000000F+01	F(X)=	10163287E+01
PT.	NO.	X	319	X=	328000000F+01	F(X)=	10155379E+01
PT.	NO.	X	320	X=	329000000F+01	F(X)=	10147607E+01
PT.	NO.	X	321	X=	330000000F+01	F(X)=	10140000E+01
PT.	NO.	X	322	X=	331000000F+01	F(X)=	10132578E+01
PT.	NO.	X	323	X=	332000000F+01	F(X)=	1012532F+01
PT.	NO.	X	324	X=	333000000F+01	F(X)=	1011820AF+01
PT.	NO.	X	325	X=	334000000F+01	F(X)=	10111205E+01
PT.	NO.	X	326	X=	335000000F+01	F(X)=	10104024E+01
PT.	NO.	X	327	X=	336000000F+01	F(X)=	10097425E+01
PT.	NO.	X	328	X=	337000000F+01	F(X)=	10090593E+01
PT.	NO.	X	329	X=	338000000F+01	F(X)=	10083763F+01
PT.	NO.	X	330	X=	339000000F+01	F(X)=	10078408E+01
PT.	NO.	X	331	X=	340000000F+01	F(X)=	10070000F+01
PT.	NO.	X	332	X=	341000000F+01	F(X)=	10063019E+01
PT.	NO.	X	333	X=	342000000F+01	F(X)=	10055972F+01
PT.	NO.	X	334	X=	343000000F+01	F(X)=	10048474F+01
PT.	NO.	X	335	X=	344000000F+01	F(X)=	10041740F+01
PT.	NO.	X	336	X=	345000000F+01	F(X)=	10034584E+01
PT.	NO.	X	337	X=	346000000F+01	F(X)=	10027422E+01
PT.	NO.	X	338	X=	347000000F+01	F(Y)=	10020768F+01
PT.	NO.	X	339	X=	348000000F+01	F(X)=	10013136E+01
PT.	NO.	X	340	X=	349000000F+01	F(X)=	10006042F+01
PT.	NO.	X	341	X=	350000000F+01	F(X)=	99990000E+00
PT.	NO.	X	342	X=	351000000F+01	F(X)=	99920221E+00
PT.	NO.	X	343	X=	352000000F+01	F(X)=	99851096E+00
PT.	NO.	X	344	X=	353000000F+01	F(X)=	99782612F+00
PT.	NO.	X	345	X=	354000000F+01	F(X)=	99714754E+00
PT.	NO.	X	346	X=	355000000F+01	F(X)=	99647510F+00
PT.	NO.	X	347	X=	356000000F+01	F(X)=	99580865E+00
PT.	NO.	X	348	X=	357000000F+01	F(X)=	99514805E+00
PT.	NO.	X	349	X=	358000000F+01	F(X)=	99449317E+00
PT.	NO.	X	350	X=	359000000F+01	F(X)=	99384387E+00
PT.	NO.	X	351	X=	360000000F+01	F(X)=	99320000E+00

TABLE 2. (CONTINUED)

PT.NN = 332	$x = 361000000F + 01$	$F(x) = 99256140E + 00$
PT.NN = 333	$x = 362000000E + 01$	$F(x) = 99192779E + 00$
PT.NN = 334	$x = 363000000F + 01$	$F(x) = 99129AH4E + 00$
PT.NN = 335	$x = 364000000E + 01$	$F(x) = 99067424E + 00$
PT.NN = 336	$x = 365000000F + 01$	$F(x) = 99005366F + 00$
PT.NN = 337	$x = 366000000F + 01$	$F(x) = 98943678E + 00$
PT.NN = 338	$x = 367000000F + 01$	$F(x) = 98822330E + 00$
PT.NN = 339	$x = 368000000E + 01$	$F(x) = 98821724F + 00$
PT.NN = 340	$x = 369000000F + 01$	$F(x) = 98760523E + 00$
PT.NN = 341	$x = 370000000F + 01$	$F(x) = 98700000F + 00$
PT.NN = 342	$x = 371000000E + 01$	$F(y) = 98639408E + 00$
PT.NN = 343	$x = 372000000F + 01$	$F(y) = 98579A29E + 00$
PT.NN = 344	$y = 373000000F + 01$	$F(y) = 98519A12F + 00$
PT.NN = 345	$x = 374000000E + 01$	$F(y) = 98460271E + 00$
PT.NN = 346	$x = 375000000E + 01$	$F(x) = 98401027E + 00$
PT.NN = 347	$x = 376000000F + 01$	$F(y) = 98342101E + 00$
PT.NN = 348	$x = 377000000F + 01$	$F(x) = 982H3514E + 00$
PT.NN = 349	$x = 37H000000E + 01$	$F(x) = 982252A7F + 00$
PT.NN = 350	$y = 379000000 + 01$	$F(x) = 98167642E + 00$
PT.NN = 351	$y = 380000000F + 01$	$F(x) = 98110A00E + 00$
PT.NN = 352	$x = 381000000E + 01$	$F(x) = 98052970F + 00$
PT.NN = 353	$x = 382000000F + 01$	$F(x) = 97996310E + 00$
PT.NN = 354	$x = 383000000 + 01$	$F(x) = 97939048F + 00$
PT.NN = 355	$x = 384000000E + 01$	$F(x) = 97863P91E + 00$
PT.NN = 356	$x = 385000000F + 01$	$F(y) = 97828A25E + 00$
PT.NN = 357	$x = 386000000F + 01$	$F(y) = 97772317E + 00$
PT.NN = 358	$x = 387000000 + 01$	$F(x) = 97716713E + 00$
PT.NN = 359	$y = 388000000E + 01$	$F(x) = 97661162E + 00$
PT.NN = 360	$y = 389000000F + 01$	$F(x) = 97605608E + 00$
PT.NN = 361	$y = 390000000E + 01$	$F(x) = 97550000E + 00$
PT.NN = 362	$x = 391000000E + 01$	$F(x) = 97494304F + 00$
PT.NN = 363	$x = 392000000F + 01$	$F(x) = 97438572E + 00$
PT.NN = 364	$x = 393000000 + 01$	$F(x) = 97382476F + 00$
PT.NN = 365	$x = 394000000E + 01$	$F(x) = 97327284E + 00$
PT.NN = 366	$x = 395000000F + 01$	$F(x) = 97271874F + 00$
PT.NN = 367	$x = 396000000E + 01$	$F(x) = 97216713E + 00$
PT.NN = 368	$x = 397000000E + 01$	$F(x) = 97161873E + 00$
PT.NN = 369	$x = 398000000F + 01$	$F(x) = 97107426E + 00$
PT.NN = 370	$x = 399000000F + 01$	$F(x) = 97053445E + 00$
PT.NN = 371	$x = 400000000E + 01$	$F(x) = 97000000F + 00$
PT.NN = 372	$x = 401000000F + 01$	$F(x) = 96947143E + 00$
PT.NN = 373	$x = 402000000E + 01$	$F(x) = 96894P0E + 00$
PT.NN = 374	$x = 403000000F + 01$	$F(x) = 96843039E + 00$
PT.NN = 375	$x = 404000000E + 01$	$F(x) = 96791687F + 00$
PT.NN = 376	$x = 405000000F + 01$	$F(x) = 96740729F + 00$
PT.NN = 377	$x = 406000000F + 01$	$F(x) = 96690113E + 00$
PT.NN = 378	$x = 407000000F + 01$	$F(x) = 96639746E + 00$
PT.NN = 379	$x = 408000000F + 01$	$F(x) = 96589693E + 00$
PT.NN = 380	$x = 409000000E + 01$	$F(x) = 96539782E + 00$
PT.NN = 381	$x = 410000000E + 01$	$F(x) = 96490000E + 00$
PT.NN = 382	$x = 411000000E + 01$	$F(x) = 964440305E + 00$
PT.NN = 383	$x = 412000000F + 01$	$F(x) = 96390707F + 00$
PT.NN = 384	$x = 413000000F + 01$	$F(x) = 96341228F + 00$
PT.NN = 385	$x = 414000000F + 01$	$F(x) = 9629188F + 00$
PT.NN = 386	$x = 415000000E + 01$	$F(y) = 96242710F + 00$
PT.NN = 387	$x = 416000000F + 01$	$F(x) = 96193715E + 00$
PT.NN = 388	$x = 417000000E + 01$	$F(x) = 96144925E + 00$
PT.NN = 389	$x = 418000000F + 01$	$F(x) = 96096361F + 00$
PT.NN = 390	$x = 419000000F + 01$	$F(x) = 96048046E + 00$
PT.NN = 391	$x = 420000000E + 01$	$F(y) = 96000000E + 00$
PT.NN = 392	$x = 421000000F + 01$	$F(x) = 95952234E + 00$
PT.NN = 393	$x = 422000000F + 01$	$F(x) = 9590731E + 00$
PT.NN = 394	$x = 423000000E + 01$	$F(x) = 95857451E + 00$
PT.NN = 395	$x = 424000000F + 01$	$F(x) = 95810362F + 00$
PT.NN = 396	$x = 425000000F + 01$	$F(x) = 95763432F + 00$
PT.NN = 397	$x = 426000000E + 01$	$F(x) = 95716627F + 00$
PT.NN = 398	$x = 427000000F + 01$	$F(y) = 95669915E + 00$
PT.NN = 399	$x = 428000000E + 01$	$F(x) = 95623762F + 00$
PT.NN = 400	$x = 429000000F + 01$	$F(x) = 95576635F + 00$
PT.NN = 401	$x = 430000000F + 01$	$F(x) = 95530000F + 00$
PT.NN = 402	$x = 431000000F + 01$	$F(y) = 95483139F + 00$
PT.NN = 403	$x = 432000000E + 01$	$F(x) = 95436649F + 00$
PT.NN = 404	$x = 433000000F + 01$	$F(x) = 95390100E + 00$
PT.NN = 405	$x = 434000000F + 01$	$F(x) = 95343624E + 00$
PT.NN = 406	$x = 435000000F + 01$	$F(x) = 95297312F + 00$
PT.NN = 407	$x = 436000000E + 01$	$F(x) = 95251215F + 00$
PT.NN = 408	$x = 437000000F + 01$	$F(x) = 92690000F + 00$
PT.NN = 409	$x = 438000000F + 01$	$F(x) = 92630000E + 00$
PT.NN = 410	$x = 439000000F + 01$	$F(x) = 87270000E + 00$
PT.NN = 411	$x = 440000000F + 01$	$F(x) = 85380000F + 00$
PT.NN = 412	$x = 440000000E + 01$	$F(y) = 83790000F + 00$
PT.NN = 413	$x = 440000000E + 02$	$F(x) = 82420000E + 00$
PT.NN = 414	$x = 440000000F + 02$	$F(x) = 81196920E + 00$
PT.NN = 415	$x = 440000000F + 02$	$F(x) = 80045600F + 00$

TABLE 2. (CONTINUED)

PT.NO.=	416	X=	13000000E+02	F(X)=	79104403E+00
PT.NO.=	417	X=	14000000E+02	F(X)=	78213294E+00
PT.NO.=	418	X=	15000000E+02	F(X)=	77404834E+00
PT.NO.=	419	X=	16000000E+02	F(X)=	76683187E+00
PT.NO.=	420	X=	17000000E+02	F(X)=	76022118E+00
PT.NO.=	421	X=	18000000E+02	F(X)=	75415388E+00
PT.NO.=	422	X=	19000000E+02	F(X)=	74851761E+00
PT.NO.=	423	X=	20000000E+02	F(X)=	74320000E+00
PT.NO.=	424	X=	21000000E+02	F(X)=	73810636E+00
PT.NO.=	425	X=	22000000E+02	F(X)=	73321267E+00
PT.NO.=	426	X=	23000000E+02	F(X)=	72851259E+00
PT.NO.=	427	Y=	24000000E+02	F(X)=	72399977E+00
PT.NO.=	428	X=	25000000E+02	F(X)=	71966787E+00
PT.NO.=	429	X=	26000000E+02	F(X)=	71551043E+00
PT.NO.=	430	X=	27000000E+02	F(X)=	71152142E+00
PT.NO.=	431	X=	28000000E+02	F(X)=	70769420E+00
PT.NO.=	432	X=	29000000E+02	F(X)=	70402250E+00
PT.NO.=	433	X=	30000000E+02	F(X)=	70050000E+00
PT.NO.=	434	X=	31000000E+02	F(X)=	69712006E+00
PT.NO.=	435	X=	32000000E+02	F(X)=	69387441E+00
PT.NO.=	436	X=	33000000E+02	F(X)=	69075650E+00
PT.NO.=	437	X=	34000000E+02	F(X)=	68775678E+00
PT.NO.=	438	X=	35000000E+02	F(X)=	68446769E+00
PT.NO.=	439	X=	36000000E+02	F(X)=	68208119E+00
PT.NO.=	440	X=	37000000E+02	F(X)=	6793H923E+00
PT.NO.=	441	X=	38000000E+02	F(X)=	6767H374E+00
PT.NO.=	442	X=	39000000E+02	F(X)=	67425688E+00
PT.NO.=	443	X=	40000000E+02	F(X)=	67180000E+00
PT.NO.=	444	X=	41000000E+02	F(X)=	66940671E+00
PT.NO.=	445	X=	42000000E+02	F(X)=	66707410E+00
PT.NO.=	446	X=	43000000E+02	F(X)=	664H0052E+00
PT.NO.=	447	X=	44000000E+02	F(X)=	66258432E+00
PT.NO.=	448	X=	45000000E+02	F(X)=	66042386E+00
PT.NO.=	449	X=	46000000E+02	F(X)=	65831749E+00
PT.NO.=	450	X=	47000000E+02	F(X)=	65626357E+00
PT.NO.=	451	X=	48000000E+02	F(X)=	65426044E+00
PT.NO.=	452	X=	49000000E+02	F(X)=	65230647E+00
PT.NO.=	453	X=	50000000E+02	F(X)=	65040000E+00
PT.NO.=	454	X=	51000000E+02	F(X)=	64853430E+00
PT.NO.=	455	X=	52000000E+02	F(X)=	64672230E+00
PT.NO.=	456	X=	53000000E+02	F(X)=	64494684E+00
PT.NO.=	457	X=	54000000E+02	F(X)=	64321075E+00
PT.NO.=	458	X=	55000000E+02	F(X)=	64151187E+00
PT.NO.=	459	X=	56000000E+02	F(X)=	63984884E+00
PT.NO.=	460	X=	57000000E+02	F(X)=	63821710E+00
PT.NO.=	461	X=	58000000E+02	F(X)=	63661689E+00
PT.NO.=	462	Y=	59000000E+02	F(X)=	63504524E+00
PT.NO.=	463	X=	60000000E+02	F(X)=	63350000E+00
PT.NO.=	464	X=	61000000E+02	F(X)=	63197938E+00
PT.NO.=	465	X=	62000000E+02	F(X)=	63048309E+00
PT.NO.=	466	X=	63000000E+02	F(X)=	62901122E+00
PT.NO.=	467	Y=	64000000E+02	F(X)=	62756388E+00
PT.NO.=	468	X=	65000000E+02	F(X)=	62614116E+00
PT.NO.=	469	X=	66000000E+02	F(X)=	62474314E+00
PT.NO.=	470	X=	67000000E+02	F(X)=	62336992E+00
PT.NO.=	471	X=	68000000E+02	F(X)=	62202160E+00
PT.NO.=	472	X=	69000000E+02	F(X)=	62069426E+00
PT.NO.=	473	X=	70000000E+02	F(X)=	61940000E+00
PT.NO.=	474	X=	71000000E+02	F(X)=	61812670E+00
PT.NO.=	475	X=	72000000E+02	F(X)=	61687735E+00
PT.NO.=	476	X=	73000000E+02	F(X)=	61565176E+00
PT.NO.=	477	X=	74000000E+02	F(X)=	61444571E+00
PT.NO.=	478	X=	75000000E+02	F(X)=	61326099E+00
PT.NO.=	479	X=	76000000E+02	F(X)=	61209539E+00
PT.NO.=	480	X=	77000000E+02	F(X)=	61094771E+00
PT.NO.=	481	Y=	78000000E+02	F(X)=	60981672F+00
PT.NO.=	482	X=	79000000E+02	F(X)=	60870122E+00
PT.NO.=	483	X=	80000000E+02	F(X)=	60760000E+00
PT.NO.=	484	X=	81000000E+02	F(X)=	60651204E+00
PT.NO.=	485	X=	82000000E+02	F(X)=	60543710E+00
PT.NO.=	486	Y=	83000000E+02	F(X)=	60437513E+00
PT.NO.=	487	X=	84000000E+02	F(X)=	60332607E+00
PT.NO.=	488	X=	85000000E+02	F(X)=	60228487F+00
PT.NO.=	489	X=	86000000E+02	F(X)=	60126648F+00
PT.NO.=	490	X=	87000000E+02	F(X)=	60025585E+00
PT.NO.=	491	X=	88000000E+02	F(X)=	59925793E+00
PT.NO.=	492	X=	89000000E+02	F(X)=	59827266F+00
PT.NO.=	493	X=	90000000E+02	F(X)=	59730000E+00
PT.NO.=	494	X=	91000000E+02	F(X)=	596339P3E+00
PT.NO.=	495	X=	92000000E+02	F(X)=	59539183F+00
PT.NO.=	496	X=	93000000E+02	F(X)=	59445562E+00
PT.NO.=	497	X=	94000000E+02	F(X)=	59353041E+00

**TABLE 2. (CONCLUDED)**

PT.NO.=	498	X=	.95000000E+02	F(X)=	.59261703E+00
PT.NO.=	499	X=	.96000000E+02	F(X)=	.59171388E+00
PT.NO.=	500	X=	.97000000E+02	F(X)=	.59082098E+00
PT.NO.=	501	X=	.98000000E+02	F(X)=	.58993796E+00
PT.NO.=	502	X=	.99000000E+02	F(X)=	.58905443E+00
PT.NO.=	503	X=	.10000000E+03	F(X)=	.58820000E+00

**IXXX08L**

been calculated by Svehla [2] for O<sub>2</sub> and NO. However, a literature search did not reveal viscosities of O<sub>3</sub> and NO<sub>2</sub> at elevated temperatures.

A method for the calculation of the viscosity of gases is given by Bird, et al. [3]

$$\epsilon/k = 0.77 T_c \quad (11)$$

$$\sigma = 2.44 \left( \frac{T_c}{P_c} \right)^{1/3} \quad (12)$$

or

$$\sigma = 0.841 (\tilde{v}_c)^{1/3} \quad (13)$$

where these functions are utilized in the Lennard-Jones potential

$$\phi(r) = 4\epsilon \left[ \left( \frac{\sigma}{r} \right)^{12} - \left( \frac{\sigma}{r} \right)^6 \right] \quad (14)$$

For O<sub>3</sub>

$$T_c = 268^\circ K \quad P_c = 67 \text{ ATM}$$

$$\tilde{v}_c = 89.4 \text{ cm}^3/\text{gm mole} \quad MW = 48.000$$

For NO<sub>2</sub>

$$T_c = 431.0^\circ K \quad P_c = 100 \text{ ATM}$$

$$MW = 46.008$$

Utilizing (11) and (13) for O<sub>3</sub> and (11) and (12) for NO<sub>2</sub> produced the following potential functions for O<sub>3</sub> and NO<sub>2</sub>:

GAS	$\epsilon/k$	$\sigma$	MW
NO <sub>2</sub>	331.8	3.97	46.008
O <sub>3</sub>	206.4	3.76	48.000

The viscosity for each of these gases is then calculated using:

$$\mu = 2.6693 \times 10^{-5} \frac{\{(\text{MW}) T\}^{1/2}}{\sigma^2 \Omega_\mu} \quad (15)$$

Utilizing the potential functions given in *Table 2*, Equation (15), and the program developed in the previous section to calculate  $\Omega_\mu$  gives the viscosities of O<sub>3</sub> and NO<sub>2</sub>.

A program was written to accomplish this called MUCALC and a listing of this program is given in Appendix B.

*Table 3* gives the results of these calculations for NO<sub>2</sub> as a function of temperature while similar results for O<sub>3</sub> are given in *Table 4*. Finally results for the other gases of interest that have been taken from the literature are presented in *Table 5*. These gases are N<sub>2</sub>, NO, and O<sub>2</sub>. These results are given over the narrower range of temperature of interest for these reactions.

#### IV. COMPARISON OF RESULTS OF THIS METHOD WITH OTHER METHODS FOR CALCULATING MOLECULAR VISCOSITIES.

In order to determine the accuracy of the technique utilized to calculate molecular viscosities that were presented in the last section, a calculation was made for CO<sub>2</sub>, results for which can be found in the literature. Hence, the properties for CO<sub>2</sub> were introduced into the program presented in the preceding section and the molecular viscosity for CO<sub>2</sub> was calculated. The program listing for this is presented in Appendix C. Note that this program is

TABLE 3. MOLECULAR VISCOSITY OF NO<sub>2</sub> AS A FUNCTION OF TEMPERATURE

T=	200.0	DEG	K	X <sub>MU</sub> =	.708571E-04	POISES
T=	300.0	DEG	K	X <sub>MU</sub> =	.119072E-03	POISES
T=	400.0	DEG	K	X <sub>MU</sub> =	.158585E-03	POISES
T=	500.0	DEG	K	X <sub>MU</sub> =	.195469E-03	POISES
T=	600.0	DEG	K	X <sub>MU</sub> =	.230845E-03	POISES
T=	700.0	DEG	K	X <sub>MU</sub> =	.263323E-03	POISES
T=	800.0	DEG	K	X <sub>MU</sub> =	.293947E-03	POISES
T=	900.0	DEG	K	X <sub>MU</sub> =	.322422E-03	POISES
T=	1000.0	DEG	K	X <sub>MU</sub> =	.350062E-03	POISES
T=	1100.0	DEG	K	X <sub>MU</sub> =	.376161E-03	POISES
T=	1200.0	DEG	K	X <sub>MU</sub> =	.401098E-03	POISES
T=	1300.0	DEG	K	X <sub>MU</sub> =	.425039E-03	POISES
T=	1400.0	DEG	K	X <sub>MU</sub> =	.448172E-03	POISES
T=	1500.0	DEG	K	X <sub>MU</sub> =	.470553E-03	POISES
T=	1600.0	DEG	K	X <sub>MU</sub> =	.492271E-03	POISES
T=	1700.0	DEG	K	X <sub>MU</sub> =	.513371E-03	POISES
T=	1800.0	DEG	K	X <sub>MU</sub> =	.533422E-03	POISES
T=	1900.0	DEG	K	X <sub>MU</sub> =	.554007E-03	POISES
T=	2000.0	DEG	K	X <sub>MU</sub> =	.573655E-03	POISES
T=	2100.0	DEG	K	X <sub>MU</sub> =	.592902E-03	POISES
T=	2200.0	DEG	K	X <sub>MU</sub> =	.611763E-03	POISES
T=	2300.0	DEG	K	X <sub>MU</sub> =	.630257E-03	POISES
T=	2400.0	DEG	K	X <sub>MU</sub> =	.648407E-03	POISES
T=	2500.0	DEG	K	X <sub>MU</sub> =	.666236E-03	POISES
T=	2600.0	DEG	K	X <sub>MU</sub> =	.683773E-03	POISES
T=	2700.0	DEG	K	X <sub>MU</sub> =	.701051E-03	POISES
T=	2800.0	DEG	K	X <sub>MU</sub> =	.718091E-03	POISES
T=	2900.0	DEG	K	X <sub>MU</sub> =	.734894E-03	POISES
T=	3000.0	DEG	K	X <sub>MU</sub> =	.751474E-03	POISES
T=	3100.0	DEG	K	X <sub>MU</sub> =	.767444E-03	POISES
T=	3200.0	DEG	K	X <sub>MU</sub> =	.784009E-03	POISES
T=	3300.0	DEG	K	X <sub>MU</sub> =	.7940097E-03	POISES
T=	3400.0	DEG	K	X <sub>MU</sub> =	.815828E-03	POISES
T=	3500.0	DEG	K	X <sub>MU</sub> =	.831510E-03	POISES
T=	3600.0	DEG	K	X <sub>MU</sub> =	.847046E-03	POISES
T=	3700.0	DEG	K	X <sub>MU</sub> =	.862436E-03	POISES
T=	3800.0	DEG	K	X <sub>MU</sub> =	.877683E-03	POISES
T=	3900.0	DEG	K	X <sub>MU</sub> =	.892788E-03	POISES
T=	4000.0	DEG	K	X <sub>MU</sub> =	.907753E-03	POISES
T=	4100.0	DEG	K	X <sub>MU</sub> =	.922579E-03	POISES
T=	4200.0	DEG	K	X <sub>MU</sub> =	.937268E-03	POISES
T=	4300.0	DEG	K	X <sub>MU</sub> =	.951822E-03	POISES
T=	4400.0	DEG	K	X <sub>MU</sub> =	.966242E-03	POISES
T=	4500.0	DEG	K	X <sub>MU</sub> =	.980531E-03	POISES
T=	4600.0	DEG	K	X <sub>MU</sub> =	.994690E-03	POISES
T=	4700.0	DEG	K	X <sub>MU</sub> =	.100872E-02	POISES
T=	4800.0	DEG	K	X <sub>MU</sub> =	.102263E-02	POISES
T=	4900.0	DEG	K	X <sub>MU</sub> =	.103641E-02	POISES
T=	5000.0	DEG	K	X <sub>MU</sub> =	.105007E-02	POISES

IXXX0EQ

TABLE 4. MOLECULAR VISCOSITY OF O<sub>3</sub> AS A FUNCTION OF TEMPERATURE

T=	200.0	DFG K	XMIJE	•114721E-03	POISES
T=	300.0	DFG K	XMIJE	•170143E-03	POISES
T=	400.0	DFG K	XMIJE	•220105E-03	POISES
T=	500.0	DFG K	XMIJE	•265016E-03	POISES
T=	600.0	DFG K	XMIJE	•305933E-03	POISES
T=	700.0	DFG K	XMIJE	•343465E-03	POISES
T=	800.0	DFG K	XMIJE	•378762E-03	POISES
T=	900.0	DFG K	XMIJE	•412005E-03	POISES
T=	1000.0	DFG K	XMIJE	•443569E-03	POISES
T=	1100.0	DFG K	XMIJE	•473715E-03	POISES
T=	1200.0	DFG K	XMIJE	•502723E-03	POISES
T=	1300.0	DFG K	XMIJE	•530744E-03	POISES
T=	1400.0	DFG K	XMIJE	•557867E-03	POISES
T=	1500.0	DFG K	XMIJE	•584165E-03	POISES
T=	1600.0	DFG K	XMIJE	•609728E-03	POISES
T=	1700.0	DFG K	XMIJE	•634665E-03	POISES
T=	1800.0	DFG K	XMIJE	•659055E-03	POISES
T=	1900.0	DFG K	XMIJE	•682913E-03	POISES
T=	2000.0	DFG K	XMIJE	•706301E-03	POISES
T=	2100.0	DFG K	XMIJE	•729279E-03	POISES
T=	2200.0	DFG K	XMIJE	•751967E-03	POISES
T=	2300.0	DFG K	XMIJE	•774195E-03	POISES
T=	2400.0	DFG K	XMIJE	•796152E-03	POISES
T=	2500.0	DFG K	XMIJE	•817781E-03	POISES
T=	2600.0	DFG K	XMIJE	•839088E-03	POISES
T=	2700.0	DFG K	XMIJE	•860081E-03	POISES
T=	2800.0	DFG K	XMIJE	•880766E-03	POISES
T=	2900.0	DFG K	XMIJE	•901149E-03	POISES
T=	3000.0	DFG K	XMIJE	•921239E-03	POISES
T=	3100.0	DFG K	XMIJE	•941044E-03	POISES
T=	3200.0	DFG K	XMIJE	•960573E-03	POISES
T=	3300.0	DFG K	XMIJE	•979836E-03	POISES
T=	3400.0	DFG K	XMIJE	•998845E-03	POISES
T=	3500.0	DFG K	XMIJE	•101761E-02	POISES
T=	3600.0	DFG K	XMIJE	•103615E-02	POISES
T=	3700.0	DFG K	XMIJE	•105447E-02	POISES
T=	3800.0	DFG K	XMIJE	•107260E-02	POISES
T=	3900.0	DFG K	XMIJE	•109054E-02	POISES
T=	4000.0	DFG K	XMIJE	•110831E-02	POISES
T=	4100.0	DFG K	XMIJE	•112594E-02	POISES
T=	4200.0	DFG K	XMIJE	•114344E-02	POISES
T=	4300.0	DFG K	XMIJE	•116052E-02	POISES
T=	4400.0	DFG K	XMIJE	•117809E-02	POISES
T=	4500.0	DFG K	XMIJE	•119524E-02	POISES
T=	4600.0	DFG K	XMIJE	•121228E-02	POISES
T=	4700.0	DFG K	XMIJE	•122920E-02	POISES
T=	4800.0	DFG K	XMIJE	•124602E-02	POISES
T=	4900.0	DFG K	XMIJE	•126273E-02	POISES
T=	5000.0	DFG K	XMIJE	•127933E-02	POISES

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TABLE 5. MOLECULAR VISCOSITIES FOR GASES INVOLVED  
IN THE  $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2$  REACTION IN A  $\text{N}_2$   
CARRIER GAS.

TEMPERATURE °K	$\mu \times 10^6$ -POISES $\text{N}_2$	$\mu \times 10^6$ -POISES $\text{O}_2$	$\mu \times 10^6$ -POISES $\text{NO}$	$\mu \times 10^6$ -POISES $\text{NO}_2$	$\mu \times 10^6$ -POISES $\text{O}_3$
200	131.3	147.9	136.5	78.9	114.7
300	177.7	206.4	192.0	119.1	170.1
400	217.2	256.5	239.7	158.6	220.1
500	252.7	301.0	282.0	195.9	265.0
600	285.4	341.4	320.5	230.8	305.9
700	315.6	379.1	356.2	263.3	343.5
800	344.0	414.8	389.9	293.9	378.8
900	371.0	448.5	421.9	322.8	412.0
1000	397.1	480.6	452.4	350.1	443.6

identical to the program presented in Appendix B except for the input conditions which are shown highlighted.

The comparison of the results from this method and that of Svehla are shown in *Table 6* for CO<sub>2</sub>. The differences between the results range from 1.4 percent at 200 degrees K and increase monotonically to 3.3 percent at 5000 degrees K. Hence the conclusion is that the calculational method results in small deviations from accepted results for gases for which the more vigorous treatment has been exercised.

## V. INTERPOLATION FOR $\mu_i = \mu_i(T)$

Having now established an interpolation routine for specie viscosities and having calculated specie viscosities for NO<sub>2</sub> and O<sub>3</sub> plus estimating the general magnitude of the error involved it was necessary to establish that the interpolation procedure was working correctly for individual species. This was accomplished by programming MUSPEC which is given in Appendix D. This program utilizes the viscosities of N<sub>2</sub>, O<sub>2</sub>, NO, NO<sub>2</sub>, and O<sub>3</sub> as input and calculates the viscosities of these species at various temperatures between 500 degrees K and 600 degrees K.

The results of these calculations are shown in *Table 7*. These results can be compared with the data presented in *Table 5*. This comparison shows that the calculations are consistent and reasonable. Hence, the procedure for the calculation at the individual viscosities has been verified before proceeding to the mixture of these gases given in the next section.

## VI. CALCULATION OF THE MOLECULAR VISCOSITY OF A MIXTURE OF GASES

Having established the calculational procedure for individual viscosities of gas species, the remaining task is to calculate same for the mixture resulting from the chemical reaction. The viscosity of the mixture of gases is not simply a mole fraction average of the individual viscosities but depends on the individual species in a more complex manner. The mathematical model due to Wilke is given [3] as follows

$$\mu_{\text{mix}} = \frac{\sum_{i=1}^n x_i \mu_i}{\sum_{j=1}^n x_j \phi_{ij}} \quad (16)$$

TABLE 6. COMPARISON OF THE VISCOSITY CALCULATED BY THE PRESENT METHOD AND THAT OF SVEHLA.

MOLECULAR VISCOSITY OF CO<sub>2</sub> AS A FUNCTION OF TEMPERATURE

T <sub>c</sub>	DEG K	X <sub>M112</sub>	★		★★	
			POISES	POISES	POISES	POISES
200.0	DEG K	X <sub>M112</sub>	101373E-03	POISES	1028 E-03	POISES
300.0	DEG K	X <sub>M112</sub>	140374E-03	POISES	1520 E-03	POISES
400.0	DEG K	X <sub>M112</sub>	142023E-03	POISES	1960 E-03	POISES
500.0	DEG K	X <sub>M112</sub>	230202E-03	POISES	2354 E-03	POISES
600.0	DEG K	X <sub>M112</sub>	264434E-03	POISES	2714 E-03	POISES
700.0	DEG K	X <sub>M112</sub>	296494E-03	POISES	3048 E-03	POISES
800.0	DEG K	X <sub>M112</sub>	324404E-03	POISES	3359 E-03	POISES
900.0	DEG K	X <sub>M112</sub>	345154E-03	POISES	3653 E-03	POISES
1000.0	DEG K	X <sub>M112</sub>	342021E-03	POISES	3931 E-03	POISES
1100.0	DEG K	X <sub>M112</sub>	407741E-03	POISES	4197 E-03	POISES
1200.0	DEG K	X <sub>M112</sub>	432507E-03	POISES	4454 E-03	POISES
1300.0	DEG K	X <sub>M112</sub>	456413E-03	POISES	4702 E-03	POISES
1400.0	DEG K	X <sub>M112</sub>	479537E-03	POISES	4942 E-03	POISES
1500.0	DEG K	X <sub>M112</sub>	501477E-03	POISES	5176 E-03	POISES
1600.0	DEG K	X <sub>M112</sub>	523945E-03	POISES	5402 E-03	POISES
1700.0	DEG K	X <sub>M112</sub>	545145E-03	POISES	5623 E-03	POISES
1800.0	DEG K	X <sub>M112</sub>	566055E-03	POISES	5837 E-03	POISES
1900.0	DEG K	X <sub>M112</sub>	586498E-03	POISES	6046 E-03	POISES
2000.0	DEG K	X <sub>M112</sub>	606558E-03	POISES	6251 E-03	POISES
2100.0	DEG K	X <sub>M112</sub>	626341E-03	POISES	6450 E-03	POISES
2200.0	DEG K	X <sub>M112</sub>	646794E-03	POISES	6646 E-03	POISES
2300.0	DEG K	X <sub>M112</sub>	664922E-03	POISES	6838 E-03	POISES
2400.0	DEG K	X <sub>M112</sub>	683741E-03	POISES	7027 E-03	POISES
2500.0	DEG K	X <sub>M112</sub>	702254E-03	POISES	7213 E-03	POISES
2600.0	DEG K	X <sub>M112</sub>	720402E-03	POISES	7398 E-03	POISES
2700.0	DEG K	X <sub>M112</sub>	738411E-03	POISES	7580 E-03	POISES
2800.0	DEG K	X <sub>M112</sub>	756075E-03	POISES	7762 E-03	POISES
2900.0	DEG K	X <sub>M112</sub>	773461E-03	POISES	7942 E-03	POISES
3000.0	DEG K	X <sub>M112</sub>	790584E-03	POISES	8122 E-03	POISES
3100.0	DEG K	X <sub>M112</sub>	807445E-03	POISES	8302 E-03	POISES
3200.0	DEG K	X <sub>M112</sub>	824107E-03	POISES	8478 E-03	POISES
3300.0	DEG K	X <sub>M112</sub>	840525E-03	POISES	8651 E-03	POISES
3400.0	DEG K	X <sub>M112</sub>	856736E-03	POISES	8821 E-03	POISES
3500.0	DEG K	X <sub>M112</sub>	872753E-03	POISES	8990 E-03	POISES
3600.0	DEG K	X <sub>M112</sub>	888596E-03	POISES	9157 E-03	POISES
3700.0	DEG K	X <sub>M112</sub>	904242E-03	POISES	9322 E-03	POISES
3800.0	DEG K	X <sub>M112</sub>	919831E-03	POISES	9485 E-03	POISES
3900.0	DEG K	X <sub>M112</sub>	935261E-03	POISES	9647 E-03	POISES
4000.0	DEG K	X <sub>M112</sub>	950574E-03	POISES	9807 E-03	POISES
4100.0	DEG K	X <sub>M112</sub>	965743E-03	POISES	9966 E-03	POISES
4200.0	DEG K	X <sub>M112</sub>	980479E-03	POISES	1012 E-02	POISES
4300.0	DEG K	X <sub>M112</sub>	994667E-03	POISES	1023 E-02	POISES
4400.0	DEG K	X <sub>M112</sub>	101075E-02	POISES	1043 E-02	POISES
4500.0	DEG K	X <sub>M112</sub>	102553E-02	POISES	1059 E-02	POISES
4600.0	DEG K	X <sub>M112</sub>	104020E-02	POISES	1074 E-02	POISES
4700.0	DEG K	X <sub>M112</sub>	105474E-02	POISES	1089 E-02	POISES
4800.0	DEG K	X <sub>M112</sub>	106926E-02	POISES	1104 E-02	POISES
4900.0	DEG K	X <sub>M112</sub>	108363E-02	POISES	1119 E-02	POISES
5000.0	DEG K	X <sub>M112</sub>	109791E-02	POISES	1134 E-02	POISES

\* PRESENT METHOD

\*\* METHOD OF SVEHLA (2)

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TABLE 7.  $\mu = \mu(T)$  FOR  $N_2$ ,  $O_2$ ,  $NO$ ,  $NO_2$ , AND  $O_3$

MII(1) =	.252700000E+03	AT T =	500.00FG K
MII(2) =	.301000000E+03	AT T =	500.00FG K
MII(3) =	.242000000E+03	AT T =	500.00FG K
MII(4) =	.145900000E+03	AT T =	500.00FG K
MII(5) =	.265000000E+03	AT T =	500.00FG K
MII(1) =	.25608922E+03	AT T =	510.00FG K
MII(2) =	.30520190E+03	AT T =	510.00FG K
MII(3) =	.28601164E+03	AT T =	510.00FG K
MII(4) =	.19949462E+03	AT T =	510.00FG K
MII(5) =	.25925554E+03	AT T =	510.00FG K
MII(1) =	.25945206E+03	AT T =	520.00FG K
MII(2) =	.30436177E+03	AT T =	520.00FG K
MII(3) =	.28996722E+03	AT T =	520.00FG K
MII(4) =	.20307346E+03	AT T =	520.00FG K
MII(5) =	.25347355E+03	AT T =	520.00FG K
MII(1) =	.26278847E+03	AT T =	530.00FG K
MII(2) =	.31348609E+03	AT T =	530.00FG K
MII(3) =	.29389742E+03	AT T =	530.00FG K
MII(4) =	.20652424E+03	AT T =	530.00FG K
MII(5) =	.27765432E+03	AT T =	530.00FG K
MII(1) =	.26609841E+03	AT T =	540.00FG K
MII(2) =	.31757172E+03	AT T =	540.00FG K
MII(3) =	.29774374E+03	AT T =	540.00FG K
MII(4) =	.21015231E+03	AT T =	540.00FG K
MII(5) =	.28174810E+03	AT T =	540.00FG K
MII(1) =	.26931185E+03	AT T =	550.00FG K
MII(2) =	.32162192E+03	AT T =	550.00FG K
MII(3) =	.30165445E+03	AT T =	550.00FG K
MII(4) =	.21365559E+03	AT T =	550.00FG K
MII(5) =	.24590520E+03	AT T =	550.00FG K
MII(1) =	.27243673E+03	AT T =	560.00FG K
MII(2) =	.32563827E+03	AT T =	560.00FG K
MII(3) =	.30543649E+03	AT T =	560.00FG K
MII(4) =	.21713442E+03	AT T =	560.00FG K
MII(5) =	.28497548E+03	AT T =	560.00FG K
MII(1) =	.27586903E+03	AT T =	570.00FG K
MII(2) =	.32962277E+03	AT T =	570.00FG K
MII(3) =	.30925522E+03	AT T =	570.00FG K
MII(4) =	.22059855E+03	AT T =	570.00FG K
MII(5) =	.29401042E+03	AT T =	570.00FG K
MII(1) =	.27907271E+03	AT T =	580.00FG K
MII(2) =	.33357664E+03	AT T =	580.00FG K
MII(3) =	.31305304E+03	AT T =	580.00FG K
MII(4) =	.22401744E+03	AT T =	580.00FG K
MII(5) =	.29800910E+03	AT T =	580.00FG K
MII(1) =	.28224471E+03	AT T =	590.00FG K
MII(2) =	.33761185E+03	AT T =	590.00FG K
MII(3) =	.31176111E+03	AT T =	590.00FG K
MII(4) =	.22742150E+03	AT T =	590.00FG K
MII(5) =	.30197220E+03	AT T =	590.00FG K

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where

$$\phi_{ij} = \frac{1}{\sqrt{8}} \left\{ 1 + \frac{MW_i}{MW_j} \right\}^{-\frac{1}{2}} \left\{ 1 + \left( \frac{\mu_i}{\mu_j} \right)^{\frac{1}{2}} \left( \frac{MW_j}{MW_i} \right)^{\frac{1}{4}} \right\}^2 \quad (17)$$

Equation (16) has been shown to reproduce measured values of  $\mu_{mix}$  to within 2 percent for certain gases. The dependence of  $\mu_{mix}$  on composition is extremely non-linear for certain gas mixtures, however.

Nevertheless, it is the best available technique and will be utilized here.

A test program was written to compute the viscosities of various mixtures of gases. The listing of this program is given in Appendix E. This program utilizes subroutine LAMVISC which performs the mixture calculations for the laminar viscosities according to the technique of Wilke given above. It also utilizes the subroutine MUSPEC which is a variation of Program MUSPEC discussed in an earlier section.

The results utilizing these methods are given in *Table 8* for various mixtures of N<sub>2</sub>, O<sub>2</sub>, NO, NO<sub>2</sub>, and O<sub>3</sub>. Comparing *Table 8* and *Table 5* will convince one that the results are reasonable.

## VII. CONCLUSIONS

A computer code has been generated to determine laminar viscosities of gases as a function of temperature. This method is approximate but it provides results useful in making engineering analyses. The specific gases for which laminar viscosities were determined included NO<sub>2</sub> and O<sub>3</sub>, but the method is applicable for other gases.

**TABLE 8.  $\mu_{mix} = \mu_{mix}(T)$  FOR VARIOUS MIXTURES OF  $N_2$ ,  $O_2$ ,  $NO$ ,  $NO_2$ , and  $O_3$  (MOLE FRACTIONS)**

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .700$   $O_2 = .300$   $NO = 0.000$   $NO_2 = 0.000$   $O_3 = 0.000$   
 $\mu_{mix} = .18631245E+03$  AT  $T = .30000000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .700$   $O_2 = .050$   $NO = .150$   $NO_2 = .050$   $O_3 = .050$   
 $\mu_{mix} = .18649147E+03$  AT  $T = .30500000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .700$   $O_2 = .100$   $NO = .100$   $NO_2 = .050$   $O_3 = .050$   
 $\mu_{mix} = .18632745E+03$  AT  $T = .35000000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .600$   $O_2 = .100$   $NO = .050$   $NO_2 = .200$   $O_3 = .050$   
 $\mu_{mix} = .22889949E+03$  AT  $T = .40000000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .500$   $O_2 = .100$   $NO = .100$   $NO_2 = .100$   $O_3 = .100$   
 $\mu_{mix} = .26701965E+03$  AT  $T = .50000000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .500$   $O_2 = .050$   $NO = .050$   $NO_2 = .200$   $O_3 = .100$   
 $\mu_{mix} = .27602886E+03$  AT  $T = .52500000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .300$   $O_2 = .300$   $NO = 0.000$   $NO_2 = 0.000$   $O_3 = 0.000$   
 $\mu_{mix} = .18631245E+03$  AT  $T = .30000000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .700$   $O_2 = .050$   $NO = .150$   $NO_2 = .050$   $O_3 = .050$   
 $\mu_{mix} = .18649147E+03$  AT  $T = .30500000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .700$   $O_2 = .100$   $NO = .100$   $NO_2 = .050$   $O_3 = .050$   
 $\mu_{mix} = .20832745E+03$  AT  $T = .35000000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .500$   $O_2 = .100$   $NO = .050$   $NO_2 = .200$   $O_3 = .050$   
 $\mu_{mix} = .22889949E+03$  AT  $T = .40000000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .500$   $O_2 = .100$   $NO = .100$   $NO_2 = .100$   $O_3 = .100$   
 $\mu_{mix} = .26701965E+03$  AT  $T = .50000000E+03$

FOR THE FOLLOWING GAS MIXTURE  $-N_2 = .500$   $O_2 = .050$   $NO = .050$   $NO_2 = .200$   $O_3 = .100$   
 $\mu_{mix} = .27602886E+03$  AT  $T = .52500000E+03$

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APPENDIX A  
PROGRAM LISTING FOR TEST - A ROUTINE TO CHECK THE  
ACCURACY OF THE CUBIC SPLINE INTERPOLATION ROUTINE



SINHOPITI THE ENTHUSIAST 74/75

FTN 496-4338 06/18/79

```

1      SUBROUTINE ENRANTS(X1*FX1*NK*5)
2      C  CALCULATION OF S(NP) AT FIRST AND LAST POINT FOR SPLINF FIT USING LAGRANGIAN
3      C POLYNOMIALS
4      DIMENSION X(1100),FX(1100),S(2)
5      DO 30 I=1,2
6      IF (I .NE. 1) GO TO 10
7      X(1)=1.2
8      S(1)=X(1)
9      X(2)=1.1
10     S(2)=X(2)
11     DO 15 K=3,20
12     X(1)=X(1)+0.1
13     X(2)=X(2)+0.1
14     K=NW
15     X=XV1(NW)
16     S=S+S(X)
17     ENDO
18
19     A0=X-X1(K-3)
20     A1=X-X1(K-2)
21     A2=X-X1(K-1)
22     A3=X-X1(K)
23     H0=X1(K-3)-X1(K-2)
24     H1=X1(K-2)-X1(K-1)
25     H2=X1(K-3)-X1(K-1)
26     C1=X1(K-2)-X1(K-1)
27     C2=X1(K-3)-X1(K-1)
28     C3=X1(K-2)-X1(K-1)
29     D1=X1(K-3)-X1(K-1)
30     D2=X1(K-2)-X1(K-1)
31     XLP01=(A1*(A2+A3)*A2*A3)/(R0*R1*G2)
32     XLP02=(A0*(A2+A3)*A2*A3)/(R1*R2*G1)
33     XLP03=(A0*(A1+A3)*A1*A3)/(R2*R3*G2)
34     XLP04=(A0*(A1+A3)*A1*A3)/(R3*R4*G3)
35     S(1)=FX1(NW-3)*XLP01*FX1(K-2)*XLP02*FX1(K-1)*XLP03*FX1(K-2)*XLP04
36
37     ENDPNP

```

```

FUNCTION PC114IC 74/74 007=1

FUNCTION PC114IC(XMAXA
DIMENSION X1(100).C
DATA 1/1/
DX=XAB-X1(1)
10 IF(1.10<30.0?0.
IF(1.10>70.30
I=-1
DX=-DXAB-X1(1)
DX=-DXAB-X1(1)
19 IF(DY)<0.30.30
DX=DY
PO IF(1.10<0.160.10.30
ODX=DXAB-X1(1+1)
ODX=DXAB-X1(1+1)
30 IF(DX)<0.19.19
PC114IC(C1.1).DX*(C
END

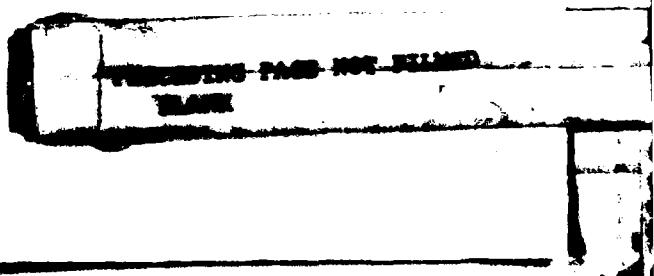
```

SUBROUTINE SPLINE 74/74 NPT=1

```
1      SUBROUTINE SPLINE(N,Y1,C)
2      DIMENSION X(100),C(4,100),D(100),DIAG(100)
3      DATA D1(1),D2(1),D3(1),D4(1),D5(1),D6(1),D7(1),D8(1),D9(1),D10(1)
4      DATA D11(1),D12(1),D13(1),D14(1),D15(1),D16(1),D17(1),D18(1),D19(1),D20(1)
5      DATA D21(1),D22(1),D23(1),D24(1),D25(1),D26(1),D27(1),D28(1),D29(1),D30(1)
6      DATA D31(1),D32(1),D33(1),D34(1),D35(1),D36(1),D37(1),D38(1),D39(1),D40(1)
7      DATA D41(1),D42(1),D43(1),D44(1),D45(1),D46(1),D47(1),D48(1),D49(1),D50(1)
8      DATA D51(1),D52(1),D53(1),D54(1),D55(1),D56(1),D57(1),D58(1),D59(1),D60(1)
9      DATA D61(1),D62(1),D63(1),D64(1),D65(1),D66(1),D67(1),D68(1),D69(1),D70(1)
10     DATA D71(1),D72(1),D73(1),D74(1),D75(1),D76(1),D77(1),D78(1),D79(1),D80(1)
11     DATA D81(1),D82(1),D83(1),D84(1),D85(1),D86(1),D87(1),D88(1),D89(1),D90(1)
12     DATA D91(1),D92(1),D93(1),D94(1),D95(1),D96(1),D97(1),D98(1),D99(1),D100(1)
13
14      NPT=N+1
15      DO 10 M=2,NPT
16      D(M)=X(M)-X(M-1)
17      D(M)=D(M)-(C(1,M)-C(1,M-1))/D(M)
18
19      DO 20 K=2,N
20      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
21      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
22      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
23      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
24      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
25      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
26      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
27      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
28      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
29      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
30      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
31      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
32      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
33      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
34      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
35      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
36      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
37      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
38      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
39      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
40      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
41      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
42      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
43      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
44      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
45      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
46      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
47      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
48      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
49      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
50      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
51      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
52      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
53      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
54      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
55      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
56      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
57      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
58      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
59      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
60      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
61      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
62      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
63      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
64      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
65      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
66      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
67      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
68      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
69      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
70      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
71      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
72      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
73      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
74      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
75      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
76      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
77      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
78      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
79      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
80      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
81      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
82      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
83      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
84      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
85      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
86      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
87      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
88      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
89      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
90      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
91      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
92      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
93      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
94      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
95      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
96      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
97      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
98      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
99      C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
100     C(2,M)=3*(D(K)+D(K-1)+D(K-2))/D(M)
101
102     RETURN
103     END
```

FTN 4.6+4338 06/18/79

**APPENDIX B**  
**PROGRAM LISTING FOR MUCALC - A ROUTINE TO**  
**CALCULATE THE MOLECULAR VISCOSITY OF NO<sub>2</sub>**  
**AND O<sub>3</sub> FROM 200 DEGREES K - 5000 DEGREES K**



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06/18/79

PROGRAM MICALC 74/74 INPUT=1 XXXREQ FTN 4.6+33K

```
66 800 FORMAT(1H1,1X,4MOLECHL VISCOSITY OF 03 AS A FUNCTION OF TEMPERAT
      1HNF,/)
  800 FORMAT(1H1,1X,4MOLECHL VISCOSITY OF N02 AS A FUNCTION OF TEMPERA
      1HNF,/)
1000 CALL EXIT
1000 STOP
1000 END
```

SUBROUTINE CALCFC - IDENTICAL TO CALCFC IN APPENDIX A  
SUBROUTINE ENDPTSL - IDENTICAL TO ENDPTSL IN APPENDIX A  
FUNCTION PCUBIC - IDENTICAL TO PCUBIC IN APPENDIX A  
SUBROUTINE SPLINE - IDENTICAL TO SPLINE IN APPENDIX A

APPENDIX C  
PROGRAM LISTING FOR MUCALC SPECIALIZED FOR  
CALCULATION OF THE MOLECULAR VISCOSITY OF CO<sub>2</sub>

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PROGRAM N1CCALC 74/74 NPT=1 IXX01V  
FOR FORMAT(1H1.1X,\*) MOLECULAR VISCOSITY OF O3 AS A FUNCTION OF TEMPERAT  
1.1E-6//  
0.01FORMAT(1H1.1X,\*) MOLECULAR VISCOSITY OF CO2 AS A FUNCTION OF TEMPERA  
.1.1E-6//  
1000 STOP  
CALL Fxit  
FN1

FTN 4.6+433R 06/18/79

60  
SUBROUTINE CALCCF - IDENTICAL TO CALCFF IN APPENDIX A  
SUBROUTINE ENDPTSL - IDENTICAL TO ENDPTSL IN APPENDIX A  
FUNCTION PCUBIC - IDENTICAL TO PCUBIC IN APPENDIX A  
SUBROUTINE SPLINE - IDENTICAL TO SPLINE IN APPENDIX A

APPENDIX D  
PROGRAM LISITNG FOR MUSPEC - A ROUTINE WHICH  
CALCULATES  $\mu = \mu_i(T)$  FOR N<sub>2</sub>, O<sub>2</sub>, NO<sub>2</sub>, NO, AND  
O<sub>3</sub> AT TEMPERATURES BETWEEN 200 DEGREES K AND 1000  
DEGREES K

06/19/79

FTN 4.64439

WJD/RAN

PROGRAM MUSPEC 74/74 npt=1

```

1      PROGRAM MUSPEC(UNITINPUT,TAPE6=OUTPUT)
2      DATA(C1(1,1),C1(1,2),C1(1,3),C1(1,4),C1(1,5),
3      C1(1,6),C1(1,7),C1(1,8),C1(1,9),C1(1,10),C1(1,11),
4      C1(1,12),C1(1,13),C1(1,14),C1(1,15),C1(1,16),
5      C1(1,17),C1(1,18),C1(1,19),C1(1,20),C1(1,21),
6      C1(1,22),C1(1,23),C1(1,24),C1(1,25),C1(1,26),
7      C1(1,27),C1(1,28),C1(1,29),C1(1,30),C1(1,31),
8      C1(1,32),C1(1,33),C1(1,34),C1(1,35),C1(1,36),
9      C1(1,37),C1(1,38),C1(1,39),C1(1,40),C1(1,41),
10     C1(1,42),C1(1,43),C1(1,44),C1(1,45),C1(1,46),
11     C1(1,47),C1(1,48),C1(1,49),C1(1,50),C1(1,51),
12     C1(1,52),C1(1,53),C1(1,54),C1(1,55),C1(1,56),
13     C1(1,57),C1(1,58),C1(1,59),C1(1,60),C1(1,61),
14     C1(1,62),C1(1,63),C1(1,64),C1(1,65),C1(1,66),
15     C1(1,67),C1(1,68),C1(1,69),C1(1,70),C1(1,71),
16     C1(1,72),C1(1,73),C1(1,74),C1(1,75),C1(1,76),
17     C1(1,77),C1(1,78),C1(1,79),C1(1,80),C1(1,81),
18     C1(1,82),C1(1,83),C1(1,84),C1(1,85),C1(1,86),
19     C1(1,87),C1(1,88),C1(1,89),C1(1,90),C1(1,91),
20     C1(1,92),C1(1,93),C1(1,94),C1(1,95),C1(1,96),
21     C1(1,97),C1(1,98),C1(1,99),C1(1,100),C1(1,101),
22     C1(1,102),C1(1,103),C1(1,104),C1(1,105),C1(1,106),
23     C1(1,107),C1(1,108),C1(1,109),C1(1,110),C1(1,111),
24     C1(1,112),C1(1,113),C1(1,114),C1(1,115),C1(1,116),
25     C1(1,117),C1(1,118),C1(1,119),C1(1,120),C1(1,121),
26     C1(1,122),C1(1,123),C1(1,124),C1(1,125),C1(1,126),
27     C1(1,127),C1(1,128),C1(1,129),C1(1,130),C1(1,131),
28     C1(1,132),C1(1,133),C1(1,134),C1(1,135),C1(1,136),
29     C1(1,137),C1(1,138),C1(1,139),C1(1,140),C1(1,141),
30     C1(1,142),C1(1,143),C1(1,144),C1(1,145),C1(1,146),
31     C1(1,147),C1(1,148),C1(1,149),C1(1,150),C1(1,151),
32     C1(1,152),C1(1,153),C1(1,154),C1(1,155),C1(1,156),
33     C1(1,157),C1(1,158),C1(1,159),C1(1,160),C1(1,161),
34     C1(1,162),C1(1,163),C1(1,164),C1(1,165),C1(1,166),
35     C1(1,167),C1(1,168),C1(1,169),C1(1,170),C1(1,171),
36     C1(1,172),C1(1,173),C1(1,174),C1(1,175),C1(1,176),
37     C1(1,177),C1(1,178),C1(1,179),C1(1,180),C1(1,181),
38     C1(1,182),C1(1,183),C1(1,184),C1(1,185),C1(1,186),
39     C1(1,187),C1(1,188),C1(1,189),C1(1,190),C1(1,191),
40     C1(1,192),C1(1,193),C1(1,194),C1(1,195),C1(1,196),
41     C1(1,197),C1(1,198),C1(1,199),C1(1,200),C1(1,201),
42     C1(1,202),C1(1,203),C1(1,204),C1(1,205),C1(1,206),
43     C1(1,207),C1(1,208),C1(1,209),C1(1,210),C1(1,211),
44     C1(1,212),C1(1,213),C1(1,214),C1(1,215),C1(1,216),
45     C1(1,217),C1(1,218),C1(1,219),C1(1,220),C1(1,221),
46     C1(1,222),C1(1,223),C1(1,224),C1(1,225),C1(1,226),
47     C1(1,227),C1(1,228),C1(1,229),C1(1,230),C1(1,231),
48     C1(1,232),C1(1,233),C1(1,234),C1(1,235),C1(1,236),
49     C1(1,237),C1(1,238),C1(1,239),C1(1,240),C1(1,241),
50     C1(1,242),C1(1,243),C1(1,244),C1(1,245),C1(1,246),
51     C1(1,247),C1(1,248),C1(1,249),C1(1,250),C1(1,251),
52     C1(1,252),C1(1,253),C1(1,254),C1(1,255),C1(1,256),
53     C1(1,257),C1(1,258),C1(1,259),C1(1,260),C1(1,261),
54     C1(1,262),C1(1,263),C1(1,264),C1(1,265),C1(1,266),
55     C1(1,267),C1(1,268),C1(1,269),C1(1,270),C1(1,271),
56     C1(1,272),C1(1,273),C1(1,274),C1(1,275),C1(1,276),
57     C1(1,277),C1(1,278),C1(1,279),C1(1,280),C1(1,281),
58     C1(1,282),C1(1,283),C1(1,284),C1(1,285),C1(1,286),
59     C1(1,287),C1(1,288),C1(1,289),C1(1,290),C1(1,291),
60     C1(1,292),C1(1,293),C1(1,294),C1(1,295),C1(1,296),
61     C1(1,297),C1(1,298),C1(1,299),C1(1,300),C1(1,301),
62     C1(1,302),C1(1,303),C1(1,304),C1(1,305),C1(1,306),
63     C1(1,307),C1(1,308),C1(1,309),C1(1,310),C1(1,311),
64     C1(1,312),C1(1,313),C1(1,314),C1(1,315),C1(1,316),
65     C1(1,317),C1(1,318),C1(1,319),C1(1,320),C1(1,321),
66     C1(1,322),C1(1,323),C1(1,324),C1(1,325),C1(1,326),
67     C1(1,327),C1(1,328),C1(1,329),C1(1,330),C1(1,331),
68     C1(1,332),C1(1,333),C1(1,334),C1(1,335),C1(1,336),
69     C1(1,337),C1(1,338),C1(1,339),C1(1,340),C1(1,341),
70     C1(1,342),C1(1,343),C1(1,344),C1(1,345),C1(1,346),
71     C1(1,347),C1(1,348),C1(1,349),C1(1,350),C1(1,351),
72     C1(1,352),C1(1,353),C1(1,354),C1(1,355),C1(1,356),
73     C1(1,357),C1(1,358),C1(1,359),C1(1,360),C1(1,361),
74     C1(1,362),C1(1,363),C1(1,364),C1(1,365),C1(1,366),
75     C1(1,367),C1(1,368),C1(1,369),C1(1,370),C1(1,371),
76     C1(1,372),C1(1,373),C1(1,374),C1(1,375),C1(1,376),
77     C1(1,377),C1(1,378),C1(1,379),C1(1,380),C1(1,381),
78     C1(1,382),C1(1,383),C1(1,384),C1(1,385),C1(1,386),
79     C1(1,387),C1(1,388),C1(1,389),C1(1,390),C1(1,391),
80     C1(1,392),C1(1,393),C1(1,394),C1(1,395),C1(1,396),
81     C1(1,397),C1(1,398),C1(1,399),C1(1,400),C1(1,401),
82     C1(1,402),C1(1,403),C1(1,404),C1(1,405),C1(1,406),
83     C1(1,407),C1(1,408),C1(1,409),C1(1,410),C1(1,411),
84     C1(1,412),C1(1,413),C1(1,414),C1(1,415),C1(1,416),
85     C1(1,417),C1(1,418),C1(1,419),C1(1,420),C1(1,421),
86     C1(1,422),C1(1,423),C1(1,424),C1(1,425),C1(1,426),
87     C1(1,427),C1(1,428),C1(1,429),C1(1,430),C1(1,431),
88     C1(1,432),C1(1,433),C1(1,434),C1(1,435),C1(1,436),
89     C1(1,437),C1(1,438),C1(1,439),C1(1,440),C1(1,441),
90     C1(1,442),C1(1,443),C1(1,444),C1(1,445),C1(1,446),
91     C1(1,447),C1(1,448),C1(1,449),C1(1,450),C1(1,451),
92     C1(1,452),C1(1,453),C1(1,454),C1(1,455),C1(1,456),
93     C1(1,457),C1(1,458),C1(1,459),C1(1,460),C1(1,461),
94     C1(1,462),C1(1,463),C1(1,464),C1(1,465),C1(1,466),
95     C1(1,467),C1(1,468),C1(1,469),C1(1,470),C1(1,471),
96     C1(1,472),C1(1,473),C1(1,474),C1(1,475),C1(1,476),
97     C1(1,477),C1(1,478),C1(1,479),C1(1,480),C1(1,481),
98     C1(1,482),C1(1,483),C1(1,484),C1(1,485),C1(1,486),
99     C1(1,487),C1(1,488),C1(1,489),C1(1,490),C1(1,491),
100    C1(1,492),C1(1,493),C1(1,494),C1(1,495),C1(1,496),
101    C1(1,497),C1(1,498),C1(1,499),C1(1,500),C1(1,501),
102    C1(1,502),C1(1,503),C1(1,504),C1(1,505),C1(1,506),
103    C1(1,507),C1(1,508),C1(1,509),C1(1,510),C1(1,511),
104    C1(1,512),C1(1,513),C1(1,514),C1(1,515),C1(1,516),
105    C1(1,517),C1(1,518),C1(1,519),C1(1,520),C1(1,521),
106    C1(1,522),C1(1,523),C1(1,524),C1(1,525),C1(1,526),
107    C1(1,527),C1(1,528),C1(1,529),C1(1,530),C1(1,531),
108    C1(1,532),C1(1,533),C1(1,534),C1(1,535),C1(1,536),
109    C1(1,537),C1(1,538),C1(1,539),C1(1,540),C1(1,541),
110    C1(1,542),C1(1,543),C1(1,544),C1(1,545),C1(1,546),
111    C1(1,547),C1(1,548),C1(1,549),C1(1,550),C1(1,551),
112    C1(1,552),C1(1,553),C1(1,554),C1(1,555),C1(1,556),
113    C1(1,557),C1(1,558),C1(1,559),C1(1,560),C1(1,561),
114    C1(1,562),C1(1,563),C1(1,564),C1(1,565),C1(1,566),
115    C1(1,567),C1(1,568),C1(1,569),C1(1,570),C1(1,571),
116    C1(1,572),C1(1,573),C1(1,574),C1(1,575),C1(1,576),
117    C1(1,577),C1(1,578),C1(1,579),C1(1,580),C1(1,581),
118    C1(1,582),C1(1,583),C1(1,584),C1(1,585),C1(1,586),
119    C1(1,587),C1(1,588),C1(1,589),C1(1,590),C1(1,591),
120    C1(1,592),C1(1,593),C1(1,594),C1(1,595),C1(1,596),
121    C1(1,597),C1(1,598),C1(1,599),C1(1,600),C1(1,601),
122    C1(1,602),C1(1,603),C1(1,604),C1(1,605),C1(1,606),
123    C1(1,607),C1(1,608),C1(1,609),C1(1,610),C1(1,611),
124    C1(1,612),C1(1,613),C1(1,614),C1(1,615),C1(1,616),
125    C1(1,617),C1(1,618),C1(1,619),C1(1,620),C1(1,621),
126    C1(1,622),C1(1,623),C1(1,624),C1(1,625),C1(1,626),
127    C1(1,627),C1(1,628),C1(1,629),C1(1,630),C1(1,631),
128    C1(1,632),C1(1,633),C1(1,634),C1(1,635),C1(1,636),
129    C1(1,637),C1(1,638),C1(1,639),C1(1,640),C1(1,641),
130    C1(1,642),C1(1,643),C1(1,644),C1(1,645),C1(1,646),
131    C1(1,647),C1(1,648),C1(1,649),C1(1,650),C1(1,651),
132    C1(1,652),C1(1,653),C1(1,654),C1(1,655),C1(1,656),
133    C1(1,657),C1(1,658),C1(1,659),C1(1,660),C1(1,661),
134    C1(1,662),C1(1,663),C1(1,664),C1(1,665),C1(1,666),
135    C1(1,667),C1(1,668),C1(1,669),C1(1,670),C1(1,671),
136    C1(1,672),C1(1,673),C1(1,674),C1(1,675),C1(1,676),
137    C1(1,677),C1(1,678),C1(1,679),C1(1,680),C1(1,681),
138    C1(1,682),C1(1,683),C1(1,684),C1(1,685),C1(1,686),
139    C1(1,687),C1(1,688),C1(1,689),C1(1,690),C1(1,691),
140    C1(1,692),C1(1,693),C1(1,694),C1(1,695),C1(1,696),
141    C1(1,697),C1(1,698),C1(1,699),C1(1,700),C1(1,701),
142    C1(1,702),C1(1,703),C1(1,704),C1(1,705),C1(1,706),
143    C1(1,707),C1(1,708),C1(1,709),C1(1,710),C1(1,711),
144    C1(1,712),C1(1,713),C1(1,714),C1(1,715),C1(1,716),
145    C1(1,717),C1(1,718),C1(1,719),C1(1,720),C1(1,721),
146    C1(1,722),C1(1,723),C1(1,724),C1(1,725),C1(1,726),
147    C1(1,727),C1(1,728),C1(1,729),C1(1,730),C1(1,731),
148    C1(1,732),C1(1,733),C1(1,734),C1(1,735),C1(1,736),
149    C1(1,737),C1(1,738),C1(1,739),C1(1,740),C1(1,741),
150    C1(1,742),C1(1,743),C1(1,744),C1(1,745),C1(1,746),
151    C1(1,747),C1(1,748),C1(1,749),C1(1,750),C1(1,751),
152    C1(1,752),C1(1,753),C1(1,754),C1(1,755),C1(1,756),
153    C1(1,757),C1(1,758),C1(1,759),C1(1,760),C1(1,761),
154    C1(1,762),C1(1,763),C1(1,764),C1(1,765),C1(1,766),
155    C1(1,767),C1(1,768),C1(1,769),C1(1,770),C1(1,771),
156    C1(1,772),C1(1,773),C1(1,774),C1(1,775),C1(1,776),
157    C1(1,777),C1(1,778),C1(1,779),C1(1,780),C1(1,781),
158    C1(1,782),C1(1,783),C1(1,784),C1(1,785),C1(1,786),
159    C1(1,787),C1(1,788),C1(1,789),C1(1,790),C1(1,791),
160    C1(1,792),C1(1,793),C1(1,794),C1(1,795),C1(1,796),
161    C1(1,797),C1(1,798),C1(1,799),C1(1,800),C1(1,801),
162    C1(1,802),C1(1,803),C1(1,804),C1(1,805),C1(1,806),
163    C1(1,807),C1(1,808),C1(1,809),C1(1,810),C1(1,811),
164    C1(1,812),C1(1,813),C1(1,814),C1(1,815),C1(1,816),
165    C1(1,817),C1(1,818),C1(1,819),C1(1,820),C1(1,821),
166    C1(1,822),C1(1,823),C1(1,824),C1(1,825),C1(1,826),
167    C1(1,827),C1(1,828),C1(1,829),C1(1,830),C1(1,831),
168    C1(1,832),C1(1,833),C1(1,834),C1(1,835),C1(1,836),
169    C1(1,837),C1(1,838),C1(1,839),C1(1,840),C1(1,841),
170    C1(1,842),C1(1,843),C1(1,844),C1(1,845),C1(1,846),
171    C1(1,847),C1(1,848),C1(1,849),C1(1,850),C1(1,851),
172    C1(1,852),C1(1,853),C1(1,854),C1(1,855),C1(1,856),
173    C1(1,857),C1(1,858),C1(1,859),C1(1,860),C1(1,861),
174    C1(1,862),C1(1,863),C1(1,864),C1(1,865),C1(1,866),
175    C1(1,867),C1(1,868),C1(1,869),C1(1,870),C1(1,871),
176    C1(1,872),C1(1,873),C1(1,874),C1(1,875),C1(1,876),
177    C1(1,877),C1(1,878),C1(1,879),C1(1,880),C1(1,881),
178    C1(1,882),C1(1,883),C1(1,884),C1(1,885),C1(1,886),
179    C1(1,887),C1(1,888),C1(1,889),C1(1,890),C1(1,891),
180    C1(1,892),C1(1,893),C1(1,894),C1(1,895),C1(1,896),
181    C1(1,897),C1(1,898),C1(1,899),C1(1,900),C1(1,901),
182    C1(1,902),C1(1,903),C1(1,904),C1(1,905),C1(1,906),
183    C1(1,907),C1(1,908),C1(1,909),C1(1,910),C1(1,911),
184    C1(1,912),C1(1,913),C1(1,914),C1(1,915),C1(1,916),
185    C1(1,917),C1(1,918),C1(1,919),C1(1,920),C1(1,921),
186    C1(1,922),C1(1,923),C1(1,924),C1(1,925),C1(1,926),
187    C1(1,927),C1(1,928),C1(1,929),C1(1,930),C1(1,931),
188    C1(1,932),C1(1,933),C1(1,934),C1(1,935),C1(1,936),
189    C1(1,937),C1(1,938),C1(1,939),C1(1,940),C1(1,941),
190    C1(1,942),C1(1,943),C1(1,944),C1(1,945),C1(1,946),
191    C1(1,947),C1(1,948),C1(1,949),C1(1,950),C1(1,951),
192    C1(1,952),C1(1,953),C1(1,954),C1(1,955),C1(1,956),
193    C1(1,957),C1(1,958),C1(1,959),C1(1,960),C1(1,961),
194    C1(1,962),C1(1,963),C1(1,964),C1(1,965),C1(1,966),
195    C1(1,967),C1(1,968),C1(1,969),C1(1,970),C1(1,971),
196    C1(1,972),C1(1,973),C1(1,974),C1(1,975),C1(1,976),
197    C1(1,977),C1(1,978),C1(1,979),C1(1,980),C1(1,981),
198    C1(1,982),C1(1,983),C1(1,984),C1(1,985),C1(1,986),
199    C1(1,987),C1(1,988),C1(1,989),C1(1,990),C1(1,991),
200    C1(1,992),C1(1,993),C1(1,994),C1(1,995),C1(1,996),
201    C1(1,997),C1(1,998),C1(1,999),C1(1,1000),C1(1,1001),
202    C1(1,1002),C1(1,1003),C1(1,1004),C1(1,1005),C1(1,1006),
203    C1(1,1007),C1(1,1008),C1(1,1009),C1(1,1010),C1(1,1011),
204    C1(1,1012),C1(1,1013),C1(1,1014),C1(1,1015),C1(1,1016),
205    C1(1,1017),C1(1,1018),C1(1,1019),C1(1,1020),C1(1,1021),
206    C1(1,1022),C1(1,1023),C1(1,1024),C1(1,1025),C1(1,1026),
207    C1(1,1027),C1(1,1028),C1(1,1029),C1(1,1030),C1(1,1031),
208    C1(1,1032),C1(1,1033),C1(1,1034),C1(1,1035),C1(1,1036),
209    C1(1,1037),C1(1,1038),C1(1,1039),C1(1,1040),C1(1,1041),
210    C1(1,1042),C1(1,1043),C1(1,1044),C1(1,1045),C1(1,1046),
211    C1(1,1047),C1(1,1048),C1(1,1049),C1(1,1050),C1(1,1051),
212    C1(1,1052),C1(1,1053),C1(1,1054),C1(1,1055),C1(1,1056),
213    C1(1,1057),C1(1,1058),C1(1,1059),C1(1,1060),C1(1,1061),
214    C1(1,1062),C1(1,1063),C1(1,1064),C1(1,1065),C1(1,1066),
215    C1(1,1067),C1(1,1068),C1(1,1069),C1(1,1070),C1(1,1071),
216    C1(1,1072),C1(1,1073),C1(1,1074),C1(1,1075),C1(1,1076),
217    C1(1,1077),C1(1,1078),C1(1,1079),C1(1,1080),C1(1,1081),
218    C1(1,1082),C1(1,1083),C1(1,1084),C1(1,1085),C1(1,1086),
219    C1(1,1087),C1(1,1088),C1(1,1089),C1(1,1090),C1(1,1091),
220    C1(1,1092),C1(1,1093),C1(1,1094),C1(1,1095),C1(1,1096),
221    C1(1,1097),C1(1,1098),C1(1,1099),C1(1,1100),C1(1,1101),
222    C1(1,1102),C1(1,1103),C1(1,1104),C1(1,1105),C1(1,1106),
223    C1(1,1107),C1(1,1108),C1(1,1109),C1(1,1110),C1(1,1111),
224    C1(1,1112),C1(1,1113),C1(1,1114),C1(1,1115),C1(1,1116),
225    C1(1,1117),C1(1,1118),C1(1,1119),C1(1,1120),C1(1,1121),
226    C1(1,1122),C1(1,1123),C1(1,1124),C1(1,1125),C1(1,1126),
227    C1(1,1127),C1(1,1128),C1(1,1129),C1(1,1130),C1(1,1131),
228    C1(1,1132),C1(1,1133),C1(1,1134),C1(1,1135),C1(1,1136),
229    C1
```

SUBROUTINE CALCCF - IDENTICAL TO CALCCF IN APPENDIX A  
SUBROUTINE ENDPTSL - IDENTICAL TO ENDPTSL IN APPENDIX A  
FUNCTION PCUBIC - IDENTICAL TO PCUBIC IN APPENDIX A  
SUBROUTINE SPLINE - IDENTICAL TO SPLINE IN APPENDIX A

**APPENDIX E**  
**PROGRAM LISTING FOR LVSCTST - A ROUTINE TO**  
**CALCULATE  $\mu_{MIX} = \mu_{MIX}(T)$  FOR MIXTURES**  
**OF  $N_2$ ,  $O_2$ ,  $NO$ ,  $NO_2$ , AND  $O_3$**



FTN 4.6.4434

WJwDK45

nppt#1

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1      SUBROUTINE MINEPC(INTMAX,T,XMAX)
2      DIMENSION C(4,9),X(4,9),S(2),C1(9,5),FX1(9),C2(4,4,5),XM(5)
3      DATA (C1(I,J),I=1,9,J=1,9)/131.3,177.7,217.2,252.7,285.4,315.6,
4      DATA (C(I,J),I=1,9,J=1,9)/347.1,347.1,347.1,347.1,347.1,347.1,
5      DATA (C(I,J),I=1,4,J=1,4)/147.9,206.4,256.5,301.0,341.4,376.1,
6      DATA (C1(I,J),I=1,4,J=1,4)/5480.6,136.5,192.0,239.7,242.0,320.6,346.0,361.0,376.1,
7      DATA (C(I,J),I=1,4,J=1,4)/139.9,457.4,74.9,139.9,74.9,139.9,139.9,139.9,139.9,
8      DATA (C(I,J),I=1,4,J=5,6)/360.1,114.7,114.7,114.7,114.7,114.7,114.7,114.7,114.7,
9      DATA (C(I,J),I=1,4,J=7,8)/360.1,114.7,114.7,114.7,114.7,114.7,114.7,114.7,114.7,
10     DATA (C(I,J),I=1,4,J=9,10)/360.1,114.7,114.7,114.7,114.7,114.7,114.7,114.7,114.7,
11     IF (INTMAX<0) GOTO 100
12     IF (INTMAX>0) GOTO 200
13     N=INTMAX
14     X(1,1)=200.0
15     DO 16 I=1,10
16     X(I,1)=X(1,1)+100.
17     DO 18 J=1,10
18     X(1,J)=X(1,1)+100.
19     DO 20 I=1,10
20     X(I,J)=X(1,1)+100.
21     C(1,1)=C(1,1)+1
22     C(1,2)=C(1,2)+1
23     C(2,1)=C(2,1)+1
24     C(2,2)=C(2,2)+1
25     CALL SPLINE(N,X(1),FX1,N),S
26     CALL CALCCF(N,X(1),C)
27     DO 28 I=1,4
28     C2(I,J)=0.0
29     DO 30 J=1,4
30     C2(I,J)=C2(I,J)+C(I,J)
31     DO 32 I=1,4
32     CNT=1
33     DO 34 J=1,4
34     CNT=1
35     DO 36 K=1,4
36     C(I,J)=C(I,J)+C(K,J)
37     DO 38 K=1,4
38     C(I,J)=C(I,J)+C(I,K)
39     XMAX=XMAX+C(I,J)
40     CNT=1
41     DO 42 K=1,4
42     CNT=1
43     DO 44 J=1,4
44     CNT=1
45     DO 46 I=1,4
46     CNT=1
47     XMAX=XMAX+C(I,J)
48     CNT=1
49     DO 50 K=1,4
50     CNT=1
51     DO 52 J=1,4
52     CNT=1
53     DO 54 I=1,4
54     CNT=1
55     DO 56 K=1,4
56     CNT=1
57     DO 58 J=1,4
58     CNT=1
59     DO 60 I=1,4
60     CNT=1
61     XMAX=XMAX+C(I,J)
62     CNT=1
63     DO 64 K=1,4
64     CNT=1
65     DO 66 J=1,4
66     CNT=1
67     DO 68 I=1,4
68     CNT=1
69     DO 70 K=1,4
70     CNT=1
71     DO 72 J=1,4
72     CNT=1
73     DO 74 I=1,4
74     CNT=1
75     DO 76 K=1,4
76     CNT=1
77     DO 78 J=1,4
78     CNT=1
79     DO 80 I=1,4
80     CNT=1
81     XMAX=XMAX+C(I,J)
82     CNT=1
83     DO 84 K=1,4
84     CNT=1
85     DO 86 J=1,4
86     CNT=1
87     DO 88 I=1,4
88     CNT=1
89     DO 90 K=1,4
90     CNT=1
91     DO 92 J=1,4
92     CNT=1
93     DO 94 I=1,4
94     CNT=1
95     DO 95 K=1,4
95     CNT=1
96     DO 97 J=1,4
97     CNT=1
98     DO 99 I=1,4
99     CNT=1
100    XMAX=XMAX+C(I,J)
101    CNT=1
102    DO 103 K=1,4
103    CNT=1
104    DO 105 J=1,4
105    CNT=1
106    DO 107 I=1,4
107    CNT=1
108    DO 109 K=1,4
109    CNT=1
110    DO 111 J=1,4
111    CNT=1
112    DO 113 I=1,4
113    CNT=1
114    DO 115 K=1,4
115    CNT=1
116    DO 117 J=1,4
117    CNT=1
118    DO 119 I=1,4
119    CNT=1
120    DO 121 K=1,4
121    CNT=1
122    DO 123 J=1,4
123    CNT=1
124    DO 125 I=1,4
125    CNT=1
126    DO 126 K=1,4
126    CNT=1
127    DO 127 J=1,4
127    CNT=1
128    DO 128 I=1,4
128    CNT=1
129    DO 130 K=1,4
130    CNT=1
131    DO 131 J=1,4
131    CNT=1
132    DO 132 I=1,4
132    CNT=1
133    DO 133 K=1,4
133    CNT=1
134    DO 134 J=1,4
134    CNT=1
135    DO 135 I=1,4
135    CNT=1
136    DO 136 K=1,4
136    CNT=1
137    DO 137 J=1,4
137    CNT=1
138    DO 138 I=1,4
138    CNT=1
139    DO 139 K=1,4
139    CNT=1
140    DO 140 J=1,4
140    CNT=1
141    DO 141 I=1,4
141    CNT=1
142    DO 142 K=1,4
142    CNT=1
143    DO 143 J=1,4
143    CNT=1
144    DO 144 I=1,4
144    CNT=1
145    DO 145 K=1,4
145    CNT=1
146    DO 146 J=1,4
146    CNT=1
147    DO 147 I=1,4
147    CNT=1
148    DO 148 K=1,4
148    CNT=1
149    DO 149 J=1,4
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150    DO 150 I=1,4
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152    DO 152 J=1,4
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153    DO 153 I=1,4
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155    DO 155 J=1,4
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156    DO 156 I=1,4
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157    DO 157 K=1,4
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158    DO 158 J=1,4
158    CNT=1
159    DO 159 I=1,4
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160    DO 160 K=1,4
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161    DO 161 J=1,4
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162    DO 162 I=1,4
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163    DO 163 K=1,4
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164    DO 164 J=1,4
164    CNT=1
165    DO 165 I=1,4
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166    DO 166 K=1,4
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167    DO 167 J=1,4
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168    DO 168 I=1,4
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169    DO 169 K=1,4
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170    DO 170 J=1,4
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171    DO 171 I=1,4
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172    DO 172 K=1,4
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173    DO 173 J=1,4
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174    DO 174 I=1,4
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179    DO 179 J=1,4
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189    DO 189 I=1,4
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191    DO 191 J=1,4
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192    DO 192 I=1,4
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194    DO 194 J=1,4
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195    DO 195 I=1,4
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197    DO 197 J=1,4
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198    DO 198 I=1,4
198    CNT=1
199    DO 199 K=1,4
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200    DO 200 J=1,4
200    CNT=1
201    DO 201 I=1,4
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202    DO 202 K=1,4
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203    DO 203 J=1,4
203    CNT=1
204    DO 204 I=1,4
204    CNT=1
205    DO 205 K=1,4
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206    DO 206 J=1,4
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207    DO 207 I=1,4
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209    DO 209 J=1,4
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217    DO 217 K=1,4
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218    DO 218 J=1,4
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219    DO 219 I=1,4
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220    DO 220 K=1,4
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221    DO 221 J=1,4
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222    DO 222 I=1,4
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223    DO 223 K=1,4
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224    DO 224 J=1,4
224    CNT=1
225    DO 225 I=1,4
225    CNT=1
226    DO 226 K=1,4
226    CNT=1
227    DO 227 J=1,4
227    CNT=1
228    DO 228 I=1,4
228    CNT=1
229    DO 229 K=1,4
229    CNT=1
230    DO 230 J=1,4
230    CNT=1
231    DO 231 I=1,4
231    CNT=1
232    DO 232 K=1,4
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233    DO 233 J=1,4
233    CNT=1
234    DO 234 I=1,4
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235    DO 235 K=1,4
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236    DO 236 J=1,4
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237    DO 237 I=1,4
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238    DO 238 K=1,4
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239    DO 239 J=1,4
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240    DO 240 I=1,4
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241    DO 241 K=1,4
241    CNT=1
242    DO 242 J=1,4
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243    DO 243 I=1,4
243    CNT=1
244    DO 244 K=1,4
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SUBROUTINE CALCCF - IDENTICAL TO CALCCF IN APPENDIX A  
SUBROUTINE ENDPTSL - IDENTICAL TO ENDPTSL IN APPENDIX A  
FUNCTION PCUBIC - IDENTICAL TO PCUBIC IN APPENDIX A  
SUBROUTINE SPLINE - IDENTICAL TO SPLINE IN APPENDIX A

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## SYMBOLS

$\Omega_\mu$ -	Viscosity potential function of ( $\kappa T/\epsilon$ )
$\epsilon$ -	Characteristic energy of interaction between molecules, erg/molecule
$r$ -	Intermolecular distance, cm
$\sigma$ -	Collision diameter of a molecule, Å
$T_c$ -	Critical temperature, degrees K
$p_c$ -	Critical pressure, atm
$V_c$ -	Critical volume, gm/gm-mole
$\kappa$ -	Boltzman constant, 1.3805 erg/molecule-degrees K
$\phi(r)$ -	Lennard-Jones potential, Equation (14)
$MW_i$ -	Molecular weight, $i^{\text{th}}$ specie, gm/gm-mole
$\mu_i$ -	Molecular viscosity, $i^{\text{th}}$ specie, poise
$x_i$ -	Mole fraction, $i^{\text{th}}$ specie, dimensionless
$\Phi_{ij}$ -	Viscosity weighting function, Equation (2)

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